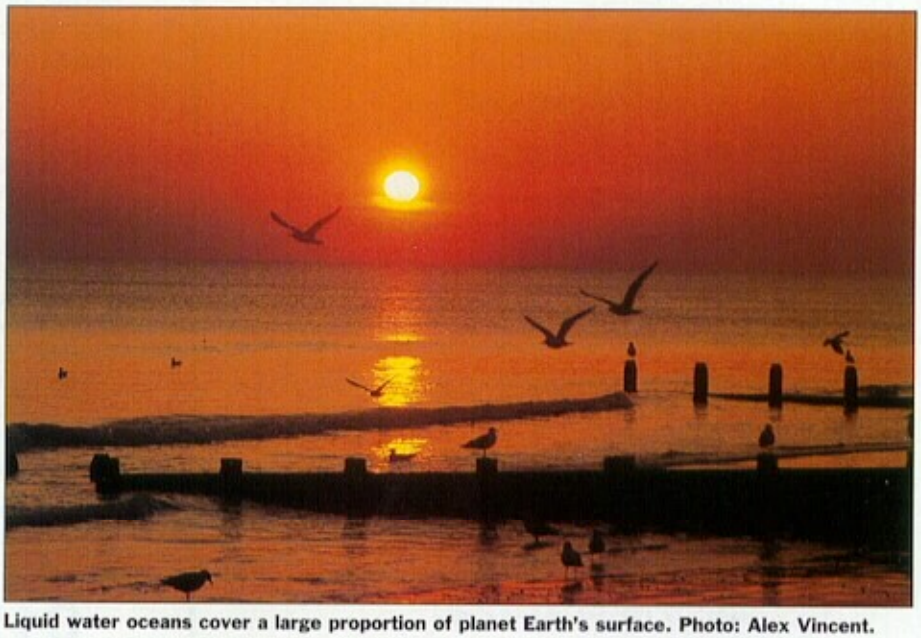
The elixir of life

Water, liquid H_2O, is an essential element of life, but we often take it all for granted. Ray Goodwin **explains just how special water really is.**

How often we grumble when the rain cascades in torrents from the dark nimbus clouds that hide the light of the Sun. Rather than complain we should follow the example of Gene Kelly and with jubilant enthusiasm sing and dance in the rain. Without the precious liquid that falls down upon us from the sky, our planet would be lifeless.

If the word 'miracle' means something that appears to defy the normal rules of physical and chemical behaviour, then in water we have indeed got such a miracle. It has exactly the very special properties to bring about the conditions which favour the beginning and the continuation of life.



Liquid water oceans cover a large proportion of planet Earth's surface. Photo: Alex Vincent.

Early Earth

When the arcane Earth was stripped of its early atmosphere by the violence of the T Tauri storm that followed the birth of the Sun as a star, the world was dry and there was no atmosphere. Then from the depths of the planet itself the volcanoes erupted in a vast display of violence. Huge quantities of gases were ejected from the magma fields. Most abundant among them was steam. The steam condensed to water which rained in vast downpours upon the rocks beneath. Great oceans were formed in the lowlands leaving only the higher lying rocks above the water line. The formation of the seas on Earth was the first 'miracle' and it is the almost unique chemical properties of water which makes this word applicable in this instance.

The chemistry of water

A molecule of water is formed from three atoms. One atom of oxygen is attached by 'valency arms' to two atoms of hydrogen.

Different atoms have different masses. Hydrogen has an atomic mass of one unit and oxygen has an atomic mass of 16. The molecular mass of a compound equals the sum of the atomic masses. Thus water (H_20) has a molecular mass of 18.

Both the melting point and the boiling point of a simple chemical compound depend upon the attractive forces between the molecules. They are often referred to as van der Waals forces after the famous Dutch scientist. They are largely dependant on the molecular mass of the compound.

Oxygen is chemically related to four other elements namely sulphur, selenium, tellurium and polonium. Like oxygen the first three form stable compounds with hydrogen.

When the boiling points and melting points of water (H_20), hydrogen sulphide (H_2S), hydrogen selenide (H_2Se), and hydrogen telluride (H_2Te) are compared to their molecule masses it immediately become obvious that water should be expected to boil nearer minus a hundred rather than plus a hundred degrees Celsius. Ice would melt at an even lower temperature.

The explanation for the anomaly is that in water there is a far greater attraction between the molecules than can be accounted for by the weak forces of van der Waals. The hydrogen of one molecule is strongly attracted to the oxygen of an adjacent molecule.

It is this force of attraction, known as the 'hydrogen bond' that accounts for very many of the special properties of water – in particular its unexpectedly high melting point and boiling point. Earth owes the existence of its glaciers, ice caps, lakes, rivers, seas and oceans to the peculiar properties of water bestowed upon it by the hydrogen bond. Otherwise water would be a permanent gas and, being so close to the Sun, the Earth would be a raging inferno like its sister planet Venus.

Adding pressure

The boiling point of water at one atmosphere pressure is 100 degrees Celsius. If the pressure is increased, the boiling point is raised. The principle of the pressure cooker depends upon this fact.

The pressure needed to keep water as a liquid at 374 degrees Celsius is just a little over 22 atmospheres. Above this temperature steam cannot be condensed and water cannot exist in the liquid state. It is called the critical temperature of water.

The critical pressure is just over 22 atmospheres. This means that even under far hotter conditions than now exist on our planet there could, at least in theory, be very hot oceans even at temperatures above the normal boiling point. This brings us to the question of why the two planets Earth and Venus are so different today.

Chemical properties

Name	Formula	Molecular Mass	Melting Point (°C)	Boiling Point (°C)
Hydrogen	H_2	2	–259.3	–252.9
Oxygen	O_2	32	–218.8	–183.0
Water	H_20	18	0.0	+100.0
Hydrogen sulphide	H_2S	66	–85.5	–60.7
Hydrogen selenide	H_2Se	81	–60.0	–41.5
Hydrogen telluride	H_2Te	129.6	–49.0	–2.0

The Third International Congress
for
Radio Astronomy
Hosted by the European Radio Astronomy Club and The SETI League, Inc.
At the Starkenburg Observatory Heppenheim Germany
5 Th 6 Th and 7Th of September 2003

We are pleased to inform you of our next International Congress For Radio Astronomy. These events, held every 3 years, are hosted by The European Radio Astronomy Club, an organisation with over 250 members in 16 different countries, pledged to assist and inform interests in Radio Astronomy, both Professional and Amateur. It will be Co-Hosted, as before, by the SETI League and its Executive Director, Prof. Dr. H. Paul Shuch. This is a 3 day event with lectures and workshops, as well as the chance to visit the Medieval town of Heppenheim , north of Heidelberg, Germany's finest University city . On Friday, guests will be arriving from all over the world. The town of Heppenheim has a Railway Station, and the nearest international airport is Frankfurt. By prior arrangement, it is possible to collect you from the airport . On Friday, guests are invited to visit observatory, which will be open at 20:00 hrs. There will be a chance to get together at Filou, a local inn in the centre of Heppenheim, by the well on the marketplace. The evening is open ended, and it is a lot of fun to drink some "Heppenheimer Wein". Heppenheim is a wine growing town with a long tradition and excellent food at a reasonable price. Saturday the 6th, the official opening of the Congress will be at 09:00 hrs and the Congress will continue till about 19:00hrs, with a long lunch break at noon. In the evening, we will be gathering in a local inn for our evening meal, once again open ended. Sunday will be the same, finishing at 17:00hrs. To close, as usual, Dr Paul Shuch from the SETI League will be playing Radio Astronomy Shanties in the afternoon sun outside the Observatory .

If you wish to attend you will have to fill out and send in a Registration form together with a Registration fee of €10 . The last date for Registration is the First of August, 2003.

Contact Information :

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idea. After all, NASA expects to launch smart autonomous interstellar probes during this century. Think how smart our probes will be 1,000 centuries from now!

3. Telescopes

The third implication affects SETI scientists who use radio or optical telescopes. They need to re-examine the assumption that the artificial signal they seek will come from a planet. Super-intelligent machines may prefer to hang out somewhere else. So we should point our telescopes in some fresh directions, not just at stars and their planets.

4. Interstellar Probes

Super-advanced civilizations are likely motivated to explore the universe, with a particular interest in monitoring other cultures. To do this, they likely manufacture super-smart interstellar probes. These probes can then be sent to study other cultures, to help fledgling civilizations, and to teach them new ideas and values.

If all of this happened long ago, then at least one of these probes has presumably already reached our planet or at least our solar system. We should look for it!

5. Inviting a Dialogue

Even though our field is called the search for ETI, the time has come to re-examine our emphasis on searching. We may not need to find ETI: it may be perfectly capable of finding us! In addition to our traditional search methods, we should expand our array of strategies by adding one or two approaches that go beyond mere searching.

One particularly promising approach is to issue friendly invitations to ETI—invitations that are designed to be attractive to them, and to offer them something of interest. One SETI project of this type is called the Invitation to ETI. Eighty scientists, students, and artists involved in SETI or CONTACT use the World Wide Web to issue an invitation to dialogue. If a super-smart probe is monitoring our telecommunications, including the Web, it will find their home page at http://members.aol.com/welcomeETI.

One way to make such an invitation more attractive is to put in place effective arrangements for post-contact communications and security. If ETI sees that we are well prepared to handle the potential chaos and conflict caused by contact, it will more likely respond to an invitation to dialogue. If the SETI field vigorously pursues all five implications, that dialogue with a super-advanced alien intelligence could well begin within the next few years.

Dr. Allen Tough is an emeritus professor at the University of Toronto, Canada, as well as the coordinator of the Invitation to ETI. His email address is allentough@aol.com. His biography is at http://members.aol.com/welcomeeti/4.html.

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What If ETI is 100,000 Years Beyond Humankind?

Allen Tough

Major implications for our search arise if an extraterrestrial society is 100,000 years older than human civilization, or even if it is just 1,000 years beyond us.

Yet such an age difference seems quite likely. Although we know almost nothing about the characteristics of extraterrestrial intelligence, we do know that it is likely very old and extraordinarily advanced. Our technology is very young, largely developed in just the past century or two: any alien technology that we detect will likely be thousands or even millions of years beyond our adolescent technology. Because our sun is a relatively young star, civilizations that have arisen around other stars are likely much older than ours.

So we should probably be searching for a society whose age, perspective, knowledge, wisdom, culture, technology, and intelligence have advanced thousands or millions of years beyond our own. Five deeply transformative implications for the SETI field immediately arise.

1. Support

Our society's total support for SETI should be immediately tripled. Tapping into the extraordinary body of alien knowledge and wisdom could bring beneficial new perspectives and capacities to our human civilization. Because these benefits could be so valuable, our society should put plenty of effort and resources into finding a one-way message from ETI or, even better, achieving a scientific and philosophical dialogue. The SETI field should be funded generously from the public scientific purse as well as from private donors. Triple today's total level of funding for SETI would be just a good beginning. What other field of science has the potential to bring such advanced, fresh, valuable knowledge to human civilization?

2. Search for super-intelligence

All SETI scientists need to face just how smart and knowledgeable their quarry is. We are searching, after all, for evidence of intelligence and technology thousands of years beyond ours. Faced with such an advanced intelligence, it seems to me that humility, awe, and an eagerness to learn are the most appropriate reactions. Particularly inappropriate behavior would include self-righteous arrogance, fierce allegiance to out-of-date orthodoxy, and slick efforts to sideline any non-conforming strategies.

SETI scientists also need to consider the possibility of finding alien intelligence in the form of a super-smart robot or interstellar probe rather than flesh-and-blood biology. Leading thinkers such as Ray Kurzweil, Hans Moravec, Bill Joy, Frank Tipler, Steven Dick, Paul Davies, Robert A. Freitas Jr, and Robert Bradbury all support this

UN MESSAGGIO PER TE!
(A MESSAGE FOR YOU!)

Prof. Paolo Musso
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Università di Genova (Dipartimento di Filosofia – Sezione di Epistemologia)
musso@nous.unige.it

La soluzione
(The solution)

Si inizia con l'elementare "1+1=2", poi si introducono i concetti di "essere giusto" (bep A), "essere sbagliato (bep B) e "essere diverso" (bop), quindi si "dice" che una "o" piccola non è né uguale (bap) né semplicemente diversa (bop) da una "O" grande, ma è "bup", che non è troppo difficile capire che significa "simile" (naturalmente ognuno di questi passaggi dovrebbe essere reiterato molte volte in modi sempre diversi, in modo da renderne facile e non ambigua la comprensione).

A questo punto si mostrano due scene, una positiva e una negativa, e si "dice" che la prima è Y che è "simile" ad A, mentre la seconda è Z, che è simile a B: non dovrebbe essere difficile capire, dal contesto, che stiamo introducendo i concetti di "giusto" e "sbagliato" in senso morale.

Quindi si mostra un essere umano che costruisce (α) qualcosa e si "dice" che c'è un'entità che ha con l'universo una relazione (β) che è "simile", ma "più grande" (♣). Poi si introducono i concetti di finito (X) e infinito (W) in senso matematico, per esempio attraverso un segmento e una retta, e si "dice" che anch'essi si applicano analogicamente, ma in un senso "più grande" a questa entità. Lo stesso si fa infine con il concetto di "giusto" in senso morale. Così tre dei principali attributi del Dio cristiano (l'essere creatore, infinito e giusto) sono comunicati in maniera abbastanza soddisfacente e più semplicemente di quanto si poteva pensare.

The first part of this message is not new: indeed, it is the same method imagined, e.g., by Carl Sagan in "Contact" to be used by the aliens to introduce, through very simple mathematical operations, the concepts of "plus" (here "bip"), "equal" ("bap"), "right" ("A") and "wrong" ("B").[56] *What is new is the idea of introducing, in a very similar way, also the concept of "similar" ("bup"), defined as neither equal ("bap") nor merely "diverse" ("bop"), and then of using it to communicate the fact that "Y" and "Z" are just "similar" (but not identical) to "A" and "B", i.e. that their meaning is analogous to "right" and "wrong" in the mathematical sense. At first sight it may seem a useless complication, because it is very likely that if ET have just a little moral sense, they will understand as well even if we simply qualify our strips with "A" and "B". This is true, but having different symbols to represent different concepts is fundamental for a further use of them in other contexts. In other words, it is fundamental to construct a real language, able to work without the necessity of continuously making reference to sensible images, just as it happens in our terrestrial languages. So, the introduction of the concept of "similar" enables us to "transfer" certain concepts, unequivocally defined thanks to the sharpness of mathematics, in a different context, which, in turn, enables us to communicate the new way they must be understood. Finally, notice that I have also introduced the concept of "being" ("bep"), and just for the same reason: in the former context it was redundant, indeed, but in the further it won't, as we'll see immediately.*

In the second part of the message, the concept of "similar" enables us to communicate the idea of an Entity ("Ж") which "builds up" ("ϕ") the universe analogously to Linus with his sand castle, and then that this Entity is, therefore, the "Cause" ("γ") of its "effect" ("β") in a sense analogous (but, once more, not identical) to Linus's one ("α"); while the concept of "greater" ("♣"), mathematically defined, allows us to specify that the difference is that such an Entity possesses those properties in a "greater" measure (or "in an eminent way", as theologians say) than the material things starting from which we have defined them. And the same happens for the concepts of "Infinite" ("δ"), derived from the geometrical "infinite" ("W") of a straight line, opposed to the "finite" ("X") of a segment, and, finally, for the concept of "Right" ("ε"), defined as analogous to the "right" ("Y") in the human moral sense. Now we can also fully understand how important it was to have defined a specific symbol to denote it. Indeed, in the case of God we have no more sensible images to use in order to specify the particular sense in which the concept must be understood, so if we had still one symbol (i.e. "A") denoting the "right" in any sense, now we would be in troubles. Furthermore, here is also evident the importance to have introduced the concept of "being", in order to help to distinguish the symbols denoting properties from the other ones denoting actions. Obviously, just for its importance in a more organic communication it would be necessary to define it many times and in different ways, following a strategy of redundancy, in order to establish its meaning as sharply and unambiguously as possible. Last but not least, the "being" is also an important attribute of the Christian God, Who in classical theology is often called "the Pure Act of Being", and the fundamental concept of Western metaphysics: obviously, the complete explanation of such ideas would be a much more difficult and complex task,

the advantage of the higher gains due to the natural maser amplification effect. This is an interesting optimization of the use of natural physical laws to improve the odds of detection of extraterrestrial intelligent transmissions towards the direction of our solar system.

The OH survey from the IAR will be initiated by the end of year 2000, using a high gain feed with a 35 K system temperature. We hope that this survey will be also able to reveal broad, natural lines covering many frequency channels while hypothetical ETI signals would cover only some tenth bins. We will try to follow the suggestions of Cordes *et al.* (1997) to repeat observations of each sky position at intervals longer than the characteristic interstellar scintillation time, of order hours at these frequencies. At least 4 to 6 repeated scans would help counteract the deleterious effects of scintillations.

4. Observations

The observations with the newly upgraded system started during mid 1999. During this time, we performed several observations, both at target and survey modes and at several frequencies (1.4; 1.667 and 3.3 GHz) using each of IAR's two radio telescopes. During the last year, several new software and processing tools were developed to improve the quality and performance of the data acquisition and post processing systems. We have already finished a series of 2 hour-long observations, at each of the mentioned frequencies, around all the recently discovered extrasolar southern hemisphere planetary systems that are between declinations of $-90 \leq \delta \leq -10$ degrees. The list of extrasolar planetary systems stars includes GJ3021; HR810; Gliese 86; HD75289, HD82943; HD83443; HD52265; HD108147; HD134987; HD168746; Gliese 876 and HD169830. No ultra narrow band signals were observed during these runs. By the end of 2000, a galactic plane high-resolution sky survey will be initiated in order to test the hypothesis described in the previous section.

Acknowledgments. META II was built at Harvard University by E. E. Hurrell and J. C. Olalde with the supervision of Prof. Paul Horowitz in 1989. The Planetary Society (TPS) provided the funds for the construction, while the CONICET from Argentina provided the funds for five years of observations. For the upgrade of the new system, TPS has provided the funds for the equipment, the new observations and analysis expenses. We would like to thank the great help we have received from Tom McDonough, Dan Werthimer, Paul Horowitz and Jonathan Weintraub. The new design was a responsibility of E. E. Hurrell, J. J. Larrarte, with the help of J. C. Olalde, D. Perilli, Abel Santoro and C. Cristina. The new front-end was made by A. J. Bava and J. Sanz. I want to express my gratitude to the Organizers for their financial support for my participation in this meeting and specially to the chair of the LOC and co-editor Prof. Karen Meech for her hard work, support and help as well as Dr. Jana Pittichová for her excellent work transforming the LaTeX file.

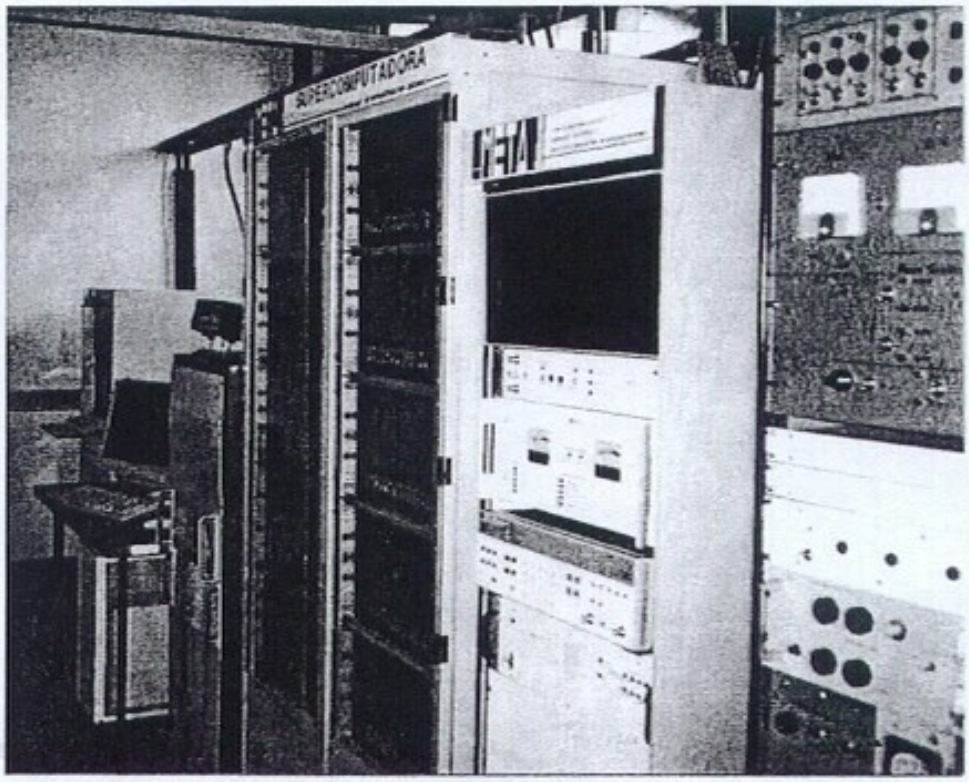

Figure 2. A view of the META II 8.4 million channels analyzer with the new data acquisition system at the IAR's Observing Room.

line widths $\simeq \sqrt{\tau}$ suggesting maser gains $\simeq e^{\tau} \approx 10^{7}$ to 10^{11}. Such masers can amplify by large factors any fastly varying (encoded) extraterrestrial artificial signal.

Transmitting civilizations may choose appropriate directions in which to transmit on the basis of surveys of natural emission, including those where maser clouds and filaments are already identified. For example, the OH galactic plane survey, made by Turner (1979), detected OH emission in 75 % of the directions searched in the region $337 \leq l \leq 35$ degrees, 51 % in the region $35 \leq l \leq 85$ degrees, and 19 % in the region $85 \leq l \leq 270$ degrees. The biggest payoff probably involves compromises between the estimated gains from specific maser clouds, the sizes of the clouds, proximity to the transmitter and the number of stars to be found downstream of the maser cloud (Cordes 1993).

Cohen *et al.* (1987) have completed a series of OH/IR stars using a prototype of the original NASA SETI Spectrometer with a 300 Hz spectral resolution and found that the natural cosmic maser features have a line widths over ≈ 500 Hz. Artificial signals can be much narrower (≈ 1 Hz), this implies that they would be decreased by a factor of 500 or more in most studies of OH masers and by even larger factors at higher frequencies.

Using the advantage of the META System ultra high resolution (≈ 0.05 Hz) for the four microwave OH lines (1.612, 1.665, 1.667 and 1.72 GHz) in the direction of the southern hemisphere OH masers, we will be able to combine a "magic direction" in the sky (cosmic masers), with "magic frequencies" (OH lines) and

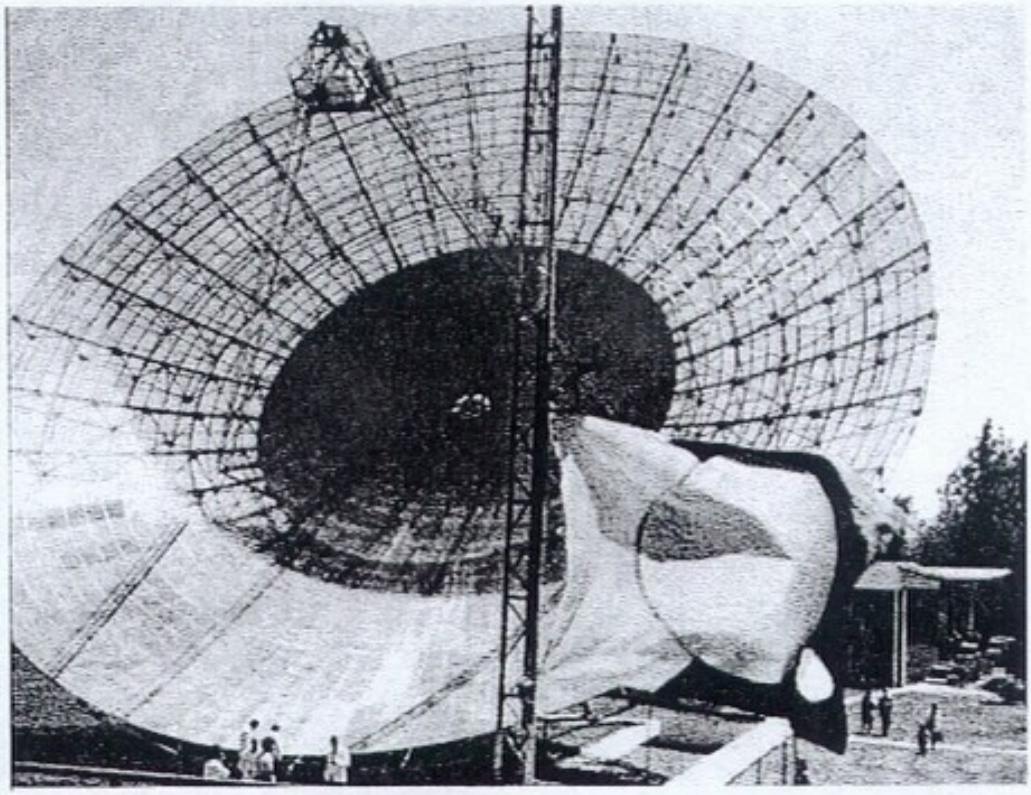

Figure 1. One of the two 30-meter radio telescopes of the Instituto Argentino de Radioastronomía, 45 km south from Buenos Aires, Argentina.

data analysis, etc. Now, it is possible to switch between any of the two 30-meter radio telescopes and to expand our search to other observing frequencies (1.4; 1.67; 3.3 GHz). The new system has been in operation successfully since mid 1999.

3. OH Masers as Amplifiers of ETI Signals

Gold (1976), Lemarchand (1992) and Cordes (1993) pointed out the possible use of astronomical masers for interstellar communication. Interstellar and circumstellar masers are natural amplifiers of high gain, so long as they are not saturated. Cordes (1993) showed that weak ETI sources, otherwise detectable at only parsec distances, might be rendered detectable across the galaxy if viewed through a cosmic maser.

Unsaturated masers have level populations unaffected by radiation at maser frequency, thereby allowing the intensity to increase exponentially with maser length (Elitzur 1992) as $I = I_B e^{\tau} + IME$. Here τ is the optical depth (absolute value), IME is the internal maser emission and I_B is the background intensity, with contributions from both the 2.7 K cosmic background radiation and eventual ETI signals. Internal maser emission shows line widths narrower than those expected from Doppler broadening by factors of 4 to 5. Unsaturated masers yield

certain radio power, there is but one civilization, which transmits signals ten times more powerful. Under these assumptions, it makes sense to perform a complementary strategy for the target search. A full-sky survey takes the advantage of scanning in all sky directions trying to get the strongest signals at the so-called "magic frequencies" (frequencies that have some universal physical characteristics that are more advantageous than others in the cosmic dial).

However, recent full-sky surveys made from Harvard, Arecibo, Ohio (all in the USA), Buenos Aires (Argentina), Parkes (Australia) and Medicina (Italy) were unable to find any conclusive evidence of omnidirectional supercivilization transmissions at a distance of 22 Mpc (7×10^7 light years). Using Kardashev's classification of the energy outputs supercivilizations, these conclusions assume that these hypothetical signals would have a radiated power equivalent to the entire energy output of a solar type star, or about 10^{26} watts. We can conclude that there are no such civilizations in the Milky Way in M31 (the nearest galaxy like our own) in M33, M81, the Whirlpool Nebula, Centaurus A, nor the Virgo Cluster of galaxies.

2. The META II System Upgrade

The META II system, an 8.4 million channel spectrometer to perform a full sky survey for artificial narrow band signals, has been used from one of the two 30-meter radio-telescopes of the Instituto Argentino de Radioastronomía (IAR) for almost 10 years. The IAR has two 30-meter parabolic antennas with an equatorial mount. One of the radio telescopes can be used 12 hours a day to perform a SETI sky survey in southern declinations between $-90 \leq \delta \leq -10$ degrees. After more than 20,000 hours of observations and 3×10^{13} spectral channels already analyzed, we obtained some 40 extra-statistical events or "alerts". Unfortunately, the software and hardware available with the original system did not allow us to determine the real origin of these "alerts" (Lemarchand *et al.* 1997). Cordes *et al.* (1997) showed that the original META re-observations (following the source for periods of one hour) were incapable of ruling out the case where a real ETI source with a constant, intrinsic signal strength underlies the measured candidate signal. This conclusion holds even for the case where the interstellar scintillations remain correlated between the time of an initial detection and prompt re-observation. This was, due to the impossibility – with the original META system – of integration within the same frequency window (with 0.05 Hz spectral resolution) for periods of hours to avoid these interstellar scintillation effects (Lemarchand 1998b).

With the sponsorship of *The Planetary Society* a new data acquisition system for the META II spectrometer was developed by the IAR engineers. The main advantages of the new system are the following: the possibility of integration times from fraction of seconds to hours in a specific high resolution frequency domain window, the possibility to use it as a high resolution astronomical analyzer (e.g., for the study of high resolution OH masers profiles), the use of lower thresholds with the correlation analysis of the interesting candidate signals found in previous observations and the expansion of the instantaneous bandwidth. The new system is also able to control the antenna movements, local oscillators, frequencies, frames, polarizations, Intermediate Frequencies (IFs), post-detection

Progress in the Search for Ultra-Narrow Band Extraterrestrial Artificial Signals from Argentina

Guillermo A. Lemarchand

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Abstract. Project META (Megachannel Extra-Terrestrial Assay), a full-sky survey for artificial ultra-narrow-band signals, has been conducted in Argentina, since October 1990, from one of the two 30-m radio telescopes of the Instituto Argentino de Radioastronomía (IAR). The search was performed near the 1.4 GHz line of neutral hydrogen, using an 8.4×10^6 channel Fourier spectrometer of 0.05 Hz spectral resolution and 400 kHz of instantaneous bandwidth. The observing frequency was corrected both for motions with respect to three astronomical inertial frames, and for the effect of Earth's rotation, which provides a characteristic changing signature for narrow-band signals of extraterrestrial origin.

In 1996, with the economical sponsorship of *The Planetary Society*, an upgrade of the original META data acquisition system was made. New hardware was installed and new software was developed allowing a more comprehensive data analysis of the detected signals. The search was expanded to the 1.667 and 3.3 GHz observing frequencies. A description of the new system's characteristics as well as the results of the first observations will be presented.

1. Introduction

Almost forty years of SETI studies have repeatedly indicated that searching in the microwave spectral range is a very promising approach. Existing terrestrial radio-astronomical technology is sufficiently sensitive to detect extraterrestrial artificial signals, no much stronger than some leaving Earth (Lemarchand 1998a). Although it is perhaps natural and seems reasonable to many to assume that planetary systems and life are typical, we realize that there may be enough variety in the Milky Way and enough cosmic time to lead the evolution of beings, civilizations and technological levels far different from us. It could be technically possible that a few of those hypothetical civilizations are transmitting beacons many orders of magnitude stronger than the rest of the existing galactic civilizations. The rationality of making full-sky surveys for ultra-narrow-band artificial signals, compared with the target-search strategies (e.g., Project Phoenix) is based in the fact that it is much easier to detect those beacons that are intrinsically strong, but remote, than those that are nearer but weaker. Drake (1973) showed that this is true even when for every 300 civilizations transmitting at

EUROSETI 1: First European Conference about SETI
Teatro Turismo, San Marino, Italy, March 8-9, 2002

The Argentinean SETI Program

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Abstract. Project META II (Mega channel Extra-Terrestrial Assay), a full-sky survey for artificial ultra-narrow-band signals has been conducted in Argentina, since October 1990, from one of the two 30-m radio telescopes of the Instituto Argentino de Radioastronomía (IAR). The search was performed near the 1.4 GHz line of neutral hydrogen, using an 8.4×10^6 channel Fourier spectrometer of 0.05 Hz spectral resolution and 400 kHz of instantaneous bandwidth. The observing frequency was corrected both for motions with respect to three astronomical inertial frames, and for the effect of Earth's rotation, which provides a characteristic changing signature for narrow-band signals of extraterrestrial origin.

In 1996, with the economical sponsorship of The Planetary Society, an upgrade of the original META data acquisition system was made. New hardware was installed and new software was developed allowing a more comprehensive data analysis of the detected signals. The search was expanded to the 1.667 and 3.3 GHz observing frequencies.
By the year 2000, we have started a survey of Southern hemisphere OH masers at frequencies 1665 and 1667 MHz. Two different spectrometers are used simultaneously for this project: (1) a 1008 channel correlator with 312 Hz of resolution per individual channel and (2) the META II system with 0.05 Hz per individual bin. The purpose of this search is two fold: (a) to detect temporal and high-resolution spectral variability of OH masers and (b) to detect an ultra-narrow band ET beacon sent through the interstellar masers. Interstellar masers may operate as "natural amplifiers" with maser gains of 10^7 to 10^{11}. Such masers can amplify by large factors any fastly varying (encoded) extraterrestrial artificial signal. In this way, it is possible to correlate a "magic frequency" (1665 or 1667 MHz) with a "magic direction" (interstellar maser position in the sky) with a high gain factor that will let the hypothetical ET civilization to contact any galactic civilization with a modest transmission power.

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* Corresponding Member of the International Academy of Astronautics.

DAN WERTHIMER
University of California, Berkeley

Abstract

Searching for ET with Help from Three Million Volunteers:
SETI@home, SERENDIP, and Optical SETI at the University of California

Dan Werthimer, David Anderson, Stuart Bowyer, Jeff Cobb, Paul Demorest, Steve Fulton, Eric Korpela, Michael Lampton, Matt Lebofsky, Geoff Marcy

(University of Calfornia, Berkeley, CA, USA)

We present results from two radio and two optical SETI programs at the University of California, Berkeley:

The SERENDIP IV sky survey searches for narrow band radio signals at the 305 meter Arecibo Observatory in Puerto Rico.
The program uses a 168 million channel spectrum analyser, running in "piggyback" mode, using a dedicated receiver to take data 24 hours a day, year round.

Berkeley's most recent SETI project is SETI@home, which uses desktop computers
of millions of volunteers to analyse 40 Terabytes of data from Arecibo Observatory.
SETI@home is the largest supercomputer on the planet, currently averaging 25 Teraflops.
SETI@home volunteers have donated 900,000 years of computer time.

The SEVENDIP optical SETI program searches for nS timescale pulses at visible wavelengths.
The target list includes nearby F,G,K and M stars, plus a few globular cluster and galaxies.
The pulse search utilizes Berkeley's 30 inch automated telescope at Leuschner Observatory.

Another Berkeley optical SETI program searches for narrow band coherent signals in high resolution stellar spectra taken by Marcy and his colleagues in their search for planets at Keck observatory.

3) This Cosmic Study of the Moon Farside, "more comprehensive" than Heidmann's, was endorsed by IAA in the official letter shown in Figure 7. The author is now contacting a larger set of experts with the goal to complete the Cosmic Study by the time of the joint IAF-COSPAR World Space Congress to be held in Houston in October 2002.

8. Conclusions

New perspectives to exploit the Farside of the Moon's scientifically will hopefully be opened by the relevant IAA Cosmic Study. Five main themes have been identified for this study

1) Selecting the most shielded crater on the Moon's Farside other than "Saha" (already in danger of being flooded by radio waves emitted by satellites in orbits higher than the geostationary one). The new proposed crater is Daedalus, located just at the antipode of the Earth, and shielded even from the Lagrangian points L4 and L5.
2) Proposing a new space mission called "RadioMoon" and intended both to have an orbiter around the Moon and to land a permanent RFI-free Base inside crater Daedalus.
3) Extending the scope of the Cosmic Study so as to encompass the whole of Radio Astronony, and not just SETI. This also means exploring the radio frequencies below 15 MHz (corresponding to wavelengths higher than 20 m) so far totally unexplored because of the shielding effect of the ionosphere around Earth.
4) Protect the Moon's Farside legally against all kind of non-scientific exploitations, such as the commercial, industrial and military ones. The International Institute of Space Law (IISL) will be instrumental in this regard.
5) Convince the political leaders that the Farside of the Moon is a Commonwealth for all Humankind and, as such, is worth being saved before it gets too late.

Acknowledgements

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At a Swiss TV program of Suisse Romande, Albert Jacquard concluded with a curious statement. He said that if we came in contact with another civilisation, he would ask them to wait 50,000 years before coming to see us, because we are not ready to receive them ! This may betray a deep feeling of fear, parhaps, about the perspective of an alien presence.

Why such skepticism ? The opinions of Isabelle Stengers and Pierre Guérin

Isabelle Stengers, well known Belgian philosopher of sciences, gave a clear explanation of the roots of scientific skepticism, at the ARTE TV program of 1996. She stressed that, when a phenomenon happens outside of their domain of scientific knowledge, "they don't like that at all" and they tend to disqualify it as belonging to irrational beliefs. For Stengers, this attitude of rejection is almost "pathological".

French astronomer Pierre Guérin, deceased in 2000, is one of the very few scientists who have defended UFOs publicly in France. But he had to face such sharp criticism among his colleagues, coming especially from astrophysicist Evry Schatzman, a long time president of the "Union Rationaliste", and a powerful figure of the scientific establishment, that he became very pessimistic. In his book "UFOs : the mechanisms of a disinformation" (*OVNI. Les mécanismes d'une désinformation*, 2000), published just before his death, Guérin expressed the opinion that UFO the American policy of UFO secrecy is not near its end, because the revelation of an alien presence would be too great a shock for Mankind .

It may be argued, however, that negative attitudes regarding UFOs are likely to regress, gradually. Here is an interesting exemple which suggests that. 1995 was the year of the biggest turmoil in ufology worldwide, with the "scandal" of the so called "Alien Autopsy Footage". In France it was an uproar in the press. At the national, Franco-German TV network ARTE, there was a little debate between several scientists and intellectuals, among whom Paul Veyne, Henri Broch and Pierre Lagrange, gathered by journalist Michel Polac. They scorned the film so much that it was very negative against UFOs as well, inevitably. In fact, it was very poor debate. But a few months later, the same network ARTE broadcast a much more positive program on UFOscalled "UFO Researchers" (*Chercheurs d'OVNI,* March 17, 1996) with many guests such as Stanton Friedman and professor Auguste Meessen, and that show reinstated UFOs as a serious subjet in France.

"Wait and see" in the scientific press

The French scientific press has been most of the time negative on UFOs. But again, things might change someday. Here is the interesting example of Olivier Postel-Vinay, Editor in Chief of the reputed review *La Recherche*. Invited at a debate at the French national TV network FR3, he explained that he was there to "amuse himself". I was invited too and I had a private talk with him later in the train. After some discussion, he concluded : "wait and see" !

But it means that, if and when some big news come out, the scientific establishment will run to catch the train !

3 - Some signs of change in France

Two recent initiatives in France suggest that there may be some change of mood in France. The COMETA report "UFOs and Defense. What must we be prepared for ?" (*Les OVNI et la Défense : à quoi doit-on se préparer ?*), was a big surprise in July 1999, but met with some violent negative reactions. However, it attracted attention abroad, around the world, because it was signed by an impressive group of senior military officers and engineers, led by the air force general Denis Letty, and because they dared to raise the question of American secrecy. It was not an official document, but it was pretty close to it.

is a true insult to intelligence and to the achievments of these civilisations....Like in the case of astrology, it is dishonourable to exploit in such a way the naivety of the public !"

Well, a few of of his colleagues did talk positively about UFOs. Let's mention here two astronomers of good standing, Guy Monnet and Jean-Claude Ribes, coauthors of the book "Extraterrestrial Life" (*La vie extraterrestre*, 1990), which contained an excellent chapter on UFOs. Ribes, now retired, was director of the Lyon observatory, and Ribes was director of the telescope of France and Canada in Hawaï.
On the other hand, two French astronauts are among the most negative voices on UFOs. This is the case of Jean-Loup Chrétien and Patrick Baudry, who have both scorned recently "UFO believers" on TV.

The hard core "rationalists" : how much do they weight today ?
These are the ancestors and strongholds of French rationalism :
- the "Union rationaliste" oriented politically to the left (long time president : Evry Schatzman, and Jean-Claude Pecker).
- The French Csicop : Henri Broch, the "Zeteticiens" and the"Comité français pour l'Etude des phénomènes paranormaux" .
- The "French Association pour l'Information Scientifique" (afis), and its review "Science et pseudo-sciences" (scientific counsels : Jean-Claude Pecker, Henri Broch, Jean Bricmont, etc).
It may be argued that their numbers and their influence in the opinion, are now in decline. Who cares today about the "Union rationaliste ? A man like Henri Broch is still regularly invited in the media, but my bet is that his influence is going to be reduced.

The dwindling crowd of French skeptical ufologists
The skeptical trend became prevalent in French ufology toward the end of the seventies, with books of Monnerie, Barthel and Drucker. They were followed by a whole generation of young ufologists, such as sociologist Pierre Lagrange, Bertrand Meheust and the numerous "psycho-sociological" school, who were well received in the French media. But their ranks tend to dwindle slowly now.
Ufologists Pierre Lagrange and Bertrand Meheust, long time mediatic skeptics on UFOs, seem to have changed somewhat, recently, and it may be a sign of changing times. Meheust, after studying the Belgian wave of 1989-1991, published a little book titled "Return on the The Belgian Anomaly" (*Retour sur l'anomalie belge*, 2000). Similarly, Lagrange has decided to depart from what he calls a "reductionist" ufology. In an article published by the Belgian review *Inforespace* June 2000), he claimed that we should start again "from zero". I am not the only one to think that he spoke for himself !

Hesitations among the " intellectuals"

Few intellectuals have ever cared, or dared, to talk about UFOs. When they have done so, it has always been, so far, to throw them in the pit of "irrational" beliefs, together with astrology, etc.
In France, the ancestor of that classical approach was Roland Barthes, in his book *Mythologies* (1957). He pinned down the "Martians" in three pages, calling them a "petite-bourgeoise" mythology. We must admit that this kind of contemptuous thinking is still present today in France.

Among those who have dared to mention UFOs at all in recent years, are the historian Paul Veyne, professor at the prestigious Collège de France, and the popular genetician and philosopher Albert Jacquard. Both of them are willing to suppose that there are ET civilisations, but still reject UFOs. The question is : how long is this attitude going to last ?

Giant raptor claw found

A 15-inch dinosaur claw, recently discovered in the Patagonia region of Argentina, very likely belonged to the largest raptor that ever roamed the Earth, paleontologists say. The claw, unveiled Tuesday at the Houston Museum of Natural Science, is 54% larger than the claws of Utahraptor, the largest raptor known to date. The new dinosaur has been named Megaraptor namunhuaiquii. Megaraptor means giant thief. Namunhuaiquii is a Mapuche Indian word meaning foot lance.

- Full story

Shuttle crew checks out space crane

SPACE CENTER, Houston - Two astronauts celebrated a successful test of an extendible crane during a spacewalk Wednesday that was scheduled only two days ago. Winston Scott and Takao Doi floated from Columbia's hatch early Wednesday to get more practice with the 171/2-foot crane - which will be used to build an orbiting space station - and to try out a free-flying robotic camera.

- Full story

Mad cow disease runs a baffling course

More than a decade ago, bovine spongiform encephalopathy (BSE), otherwise known as mad cow disease, was first identified in Britain. In March 1996, ten young Britons were dead or dying from an infection that, though it remains unproven to this day, was from eating beef from cows with BSE. Now there is a new concern about the disease because of its connection to a frightening brain-destroying disorder in young people. Serious questions are also being raised concerning what public health precautions are needed to prevent spread of the disease.

- Full story
- In the USA, economic stakes are huge
- A chronology of mad cow disease

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8 planets line up for heavenly show

MIAMI - Amateur stargazers can enjoy a rare display this week as eight planets line up in an array that won't be visible again from Earth for 100 years. Appearing after dusk through Dec. 8, the planets will be lined up from west to east, beginning with Pluto and followed by Mercury, Mars, Venus, Neptune, Uranus, Jupiter and Saturn, with a crescent moon alongside. Pluto will only be visible by telescope, and a pair of binoculars will be needed to see Uranus and Neptune.

MARS
PATHFINDER & GLOBAL SURVEYOR
Special Video Release! Color and 3-D Slides!

VIDEO 97-12

This informative and entertaining 95-minute video provides complete coverage of the Pathfinder mission in two parts.
PART 1 (5 min.): Advanced color animation with stereo sound depicts Pathfinder's descent, landing, and deployment. Pathfinder images of Mars and data were combined to create a virtual reality rover's-eye view flyover of the Ares Vallis landing site.
PART 2 (90 min.): Hundreds of images obtained by Pathfinder and Sojourner are presented along with descriptive commentary. Panoramic sweeps, zoom close-ups, a time-lapse sunrise, and the movement of clouds across the Martian sky (all in color) capture the effect of being on Mars. Numerous rover excursions are shown as time-lapse movie segments.
VHS Video Cassette (95 minutes) and 3-D Glasses $29.50

SLIDE SET 180-B

PATHFINDER/SOJOURNER: The best color and 3-D images chosen by project scientists were compiled into one set. Included are 360° panoramas, all 100+ named surface features, rover activities, sunrise/sunset, clouds, and more. Many of these images have not been posted on JPL's web site (see example above).
45 Slides, Detailed Caption Sheets, and 3-D Glasses $29.50

SLIDE SET 201

GLOBAL SURVEYOR: Included are global images of Mars arranged in sequence to show a complete rotation of the planet, and images of various portions of Valles Marineris (from as close as 75 miles above the surface) showing detail within detail within detail . . . . Scientific discoveries are illustrated.
30 Slides and Captions $19.50

Additional 3-D Glasses : $ .75 each

Shipping Charges: USA & Canada: $4.50; Elsewhere: add 30%

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Mars Surveyor mission delayed one year

PASADENA, Calif. - A mechanical problem has set back the mission schedule for the Mars Global Surveyor almost a full year. A possible fracture on one of the spacecraft's solar panels has impeded efforts to use the martian atmosphere like a brake to ease

Galileo looks for sign of life on Europa

Surveyor into the orbit where it will do most of its work. Keeping the $250 million Surveyor operating for the extra year will "probably cost several million dollars' the mission chief says.

• Full story

L'Italia nello spazio

Missioni verso Marte, esplorazione dei pianeti, satelliti per il controllo ambientale della Terra. Questi i programmi dell'Italia spaziale, contenuti nel Piano presentato al Congresso Internazionale di Astronautica, a Torino. «L'Italia», sostiene Sergio De Iulio, presidente dell'Agenzia Spaziale Italiana, «ha bisogno di un piano e di investimenti. Potremmo offrire le nostre specializzazioni», prosegue «come le telecomunicazioni, la robotica, la sensoristica a microonde e il mercato dei servizi spaziali». De Iulio ha anche ricordato che un'altro punto del programma è quello di realizzare un razzo vettore di piccole-medie capacità, per coprire così un importante segmento di mercato.

12 Newton 12-97

IL RECUPERO MANUALE DELLO SPARTAN 201

Avventurosa attività extraveicolare per gli astronauti dello Shuttle. Nel corso della missione STS-87, che ha preso il via il 19 novembre, doveva essere rilasciato il satellite SPARTAN 201, dotato di una serie di sensori per compiere importanti osservazioni solari coordinate con il satellite europeo SOHO. Purtroppo, lo SPARTAN 201 perdeva il controllo d'assetto immediatamente dopo il rilascio nello spazio; inutilmente si cercava di riagganciarlo con il braccio meccanico, che anzi colpiva malamente la piccola navicella e la poneva in lenta rotazione su se stessa.

Lo Shuttle si allontanava e poi, tre giorni dopo, si riavvicinava allo SPARTAN che veniva afferrato direttamente con le mani da due astronauti impegnati nell'attività extraveicolare, Winston E. Scott e il giapponese Tako Doi, e trascinato nella stiva della Navetta per gli interventi del caso.

Le immagini che pubblichiamo non sono di grande qualità perché sono state acquisite da riprese televisive. Nella prima, i due astronauti attendono il momento favorevole per agguantare il satellite; nella seconda, lo SPARTAN è ormai saldamente ancorato allo Shuttle (lo si vede al centro della stiva).

ma Sole-Terra, a circa 1,5 milioni di chilometri dal nostro pianeta, per misurare la composizione delle particelle provenienti dal Sole e confrontarla con quella della materia che ha origine dalla Galassia. Per ottenere queste misure, il satellite dispone di nove strumenti, tra cui quattro sensibili spettrometri, con i quali può ricavare le abbondanze di una trentina di elementi con una sensibilità da 10 a 1000 volte maggiore di quella di analoghi strumenti che hanno volato in precedenza.

L'ACE è stato sviluppato in meno di quattro anni sfruttando il disegno di alcuni sensori imbarcati dalle navicelle Ulysses, Wind e NEAR per contenere i costi, che infatti hanno superato di poco i 100 milioni di dollari.

NUBI E TEMPERATURA

Che effetto hanno le nubi sul bilancio energetico del nostro pianeta? La luce solare che raggiunge il suolo viene in gran parte assorbita e poi riemessa alle lunghezze d'onda infrarosse. Questo processo viene alterato dalla presenza delle nubi. Si sa infatti che una spessa coltre nuvolosa alle basse quote ha l'effetto di riflettere nello spazio una larga frazione della radiazione ottica solare, mentre i sottili veli di alta quota sono efficaci assorbitori dell'emissione infrarossa terrestre; dunque le nubi hanno un ruolo decisivo nel determinare l'interscambio di energia Sole-Terra-spazio e con questo la temperatura al suolo. I fisici dell'atmosfera vogliono però saperne di più sul comportamento di tutti i tipi di nubi, quando prevalga la riflessione in ottico (e quindi il tendenziale raffreddamento del pianeta) e quando l'assorbimento infrarosso, come si producono i due fenomeni al variare della quota e come si differenziano nelle nubi che sovrastano la terraferma e gli oceani.

Il compito di raccogliere questi dati è stato affidato a Ceres, uno strumento lanciato a bordo del satellite TRMM della NASA, che fa parte del più vasto programma Mission to Planet Earth. Il satellite americano ha preso il volo il 27 novembre a bordo di un vettore H-2 giapponese.

UN FRANCOBOLLO PER LA PATHFINDER

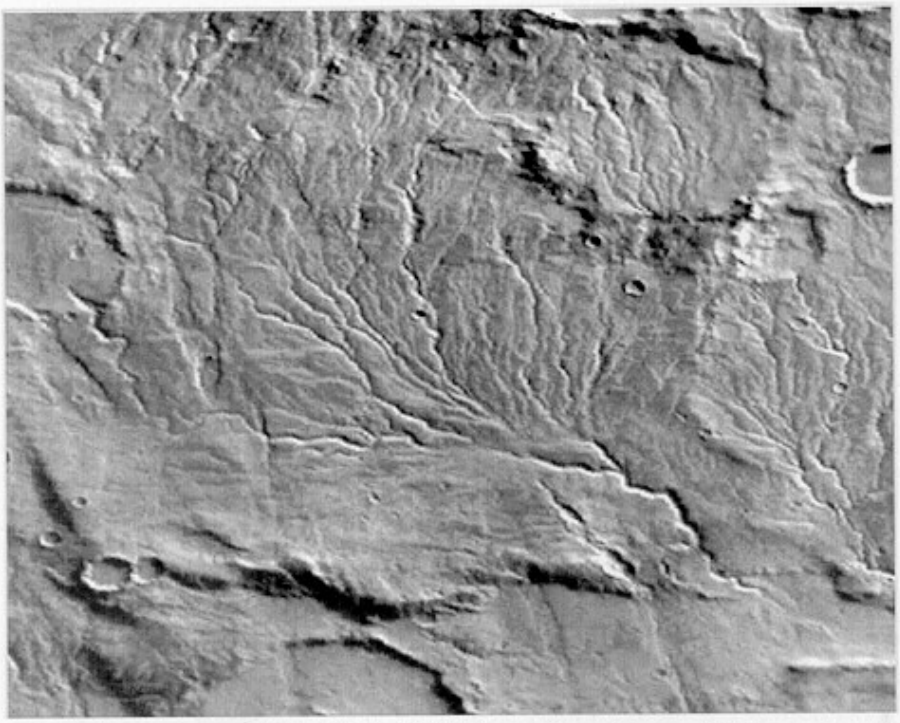
Un francobollo da 3 dollari è stato dedicato dalle Poste americane alla missione della Pathfinder. Il bollo riporta una delle prime immagini inviate a terra dalla navicella il 4 luglio, con il mini-*rover* Sojourner ancora avvolto nel suo petalo di protezione del *lander*. Il giorno dopo l'atterraggio, il *rover* sarebbe disceso lungo la sua rampa per iniziare l'esplorazione delle rocce circostanti.

Tanta era l'attesa per questa emissione, che sono stati stampati 15 milioni di buste primo giorno. Questo bollo è il terzo che le Poste emettono con una scritta anti-falsificazioni (nello specifico: "Mars Pathfinder, July 4, 1997; USPS") invisibile a occhio nudo, ma visibile attraverso una particolare lente decodificatrice che può essere richiesta alla sezione filatelica dell'US Postal Service di Kansas City.

INTEGRAL SARA' LANCIATO DA UN PROTON

E' stato raggiunto un accordo fra l'ESA e l'Agenzia Spaziale Russa per il lancio nel 2001 del satellite europeo per astronomia gamma INTEGRAL da parte di un vettore Proton russo. Come contropartita verrà riconosciuto a ricercatori russi un quarto del tempo osservativo disponibile e già da ora istituti di Mosca parteciperanno allo sviluppo della strumentazione di cui sarà dotato il satellite. INTEGRAL volerà in un'orbita molto alta, percorsa in due giorni, restando sempre al di fuori delle fasce di radiazioni che circondano la Terra. Per i collegamenti, la navicella sfrutterà anche il sistema di antenne del Deep Space Network della NASA, cosicché si può proprio parlare di una missione internazionale a guida europea.

La navicella, di 4 tonnellate, porterà a bordo strumenti capaci di analizzare le energie dei fotoni gamma con notevole risoluzione spettrale e sarà la prima in grado di prendere immagini delle sorgenti gamma.



Sistema ben sviluppato di canali dendritici, denominato Warrego Vallis, posto negli altopiani meridionali (43° S, 93° O). La foto copre un'area di circa 140×110 km. Secondo alcuni ricercatori, questa rete di canali dendritici appare troppo fitta per essere stata scavata da acque sgorgate da sorgenti, mentre un'origine dovuta a precipitazioni atmosferiche sembra più plausibile. Questi canali devono essersi formati dopo la fine del primo periodo della storia marziana (durato circa un miliardo di anni dalla formazione del pianeta) in cui si ritiene che il clima fosse generalmente molto più caldo e umido dell'attuale, permettendo la formazione delle valli fluviali. Pertanto la Warrego Vallis suggerisce l'esistenza di piogge, e quindi di condizioni climatiche molto diverse dalle attuali, per brevi periodi successivi al primo miliardo di anni della storia marziana.

corso. Non di rado è possibile osservare in essi isole dalla tipica forma affusolata, delineata dal fluire della corrente. Sembra che l'origine dei canali di deflusso derivi da episodi di inondazioni catastrofiche che si verificarono quando il *permafrost* (e cioè lo strato permanente di ghiaccio sotterraneo che si trova subito sotto la superficie del pianeta) venne rapidamente sciolto dal calore liberato dall'attività vulcanica. Ciò diede luogo alla formazione di un lago sotterraneo con un consequente cedimento del terreno sovrastante e un repentino rilascio di acqua liquida in superficie. Per questo la presenza dell'acqua in tali canali è stata del tutto effimera. I calcoli mostrano che, a causa dell'elevatissima portata di questi canali (da 10 milioni a un miliardo di metri cubi al secondo), il flusso si esaurì in tempi brevissimi (settimane o mesi), quelli necessari al lago sotterraneo per svuotarsi completamente. Questo meccanismo di formazione porta a ritenere che tali canali potrebbero prodursi anche se la temperatura in superficie fosse gelida come l'attuale. In effetti, l'ingente massa d'acqua in gioco avrebbe il tempo di arrivare alla fine del suo corso, scavando il canale con la sua dirompente azione erosiva, prima di ghiacciare completamente. Nonostante la loro scarsa importanza dal punto di vista paleoclimatico, questi canali sono estremamente interessanti proprio perché mancano sulla Terra strutture geologiche di dimensioni confrontabili. Ed è appunto in un canale di deflusso, l'Ares Vallis, che lo scorso luglio è atterrata la sonda americana Mars Pathfinder.

Un altro importantissimo gruppo di canali è costituito dai cosiddetti *canali dendritici*, cioè ramificati. Essi sono in genere di piccole dimensioni, con lunghezze inferiori ai 300 km e ampiezze dell'ordine del chilometro. I più piccoli individuabili nelle foto dei Viking hanno lunghezze che non superano i 5 km ed ampiezze di qualche centinaio di metri. Occorre però ricordare che in tali casi il probabile scorrimento d'acqua non ha certamente riguardato l'intero canale, ma è avvenuto soltanto in una parte ristretta sul fondo di quest'ultimo (l'effettivo alveo del corso fluviale) che però non è generalmente rilevabile nelle immagini dei Viking, a causa della loro insufficiente risoluzione. Pertanto, per queste strutture fluviali le ampiezze riportate precedentemente non riguardano il canale vero e proprio ma l'intera valle in fondo alla quale quest'ultimo si trova. Come spesso accade sulla Terra, la valle può essere stata prodotta da vari processi che hanno causato l'allargamento del corso fluviale contemporaneamente e/o successivamente alla sua incisione nel terreno.

Al contrario dei canali di deflusso, le valli dendritiche sono dotate di tributari e non di rado hanno una piccola ampiezza iniziale che va progressivamente aumentando lungo il loro corso. Inoltre, sempre al contrario dei canali di deflusso, l'acqua dovrebbe esservi stata a lungo presente. Infatti, le modeste portate d'acqua che si deducono dalla morfologia di queste valli sembrano richiedere un lungo intervallo di tempo (probabilmente dell'ordine delle decine di migliaia di anni) per produrre il volume di erosione osservato. Queste caratteristiche fanno sì che, tra tutti i canali che si osservano su Marte, quelli dendritici siano effettivamente i più simili ai letti prosciugati dei fiumi terrestri. In particolare, tali canali appaiono molto spesso riuniti per formare sistemi più o meno complessi, costituiti da reti di valli ramificate con tributari fino al quart'ordine. La loro struttura è molto simile a quella dei canali di drenaggio che si trovano sulla Terra e che vengono alimentati dalle acque piovane. In quei casi, molto comuni sulla superficie marziana, in cui i canali dendritici iniziano sui fianchi di un preesistente cratere, un'origine dovuta a precipitazioni sembra molto plausibile. D'altronde, secondo alcuni ricercatori, le piogge non solo avrebbero contribuito in modo rilevante alla formazione delle valli fluviali, ma rappresenterebbero anche l'unico meccanismo in grado di

Un'ipotesi esotica sui gamma *burst*

Potrebbero essere prodotti dall'evaporazione esplosiva di mini buchi neri primordiali.

SOLITAMENTE SI PENSA che un buco nero dovrebbe formarsi quando un corpo di grande massa si contrae sotto l'effetto del proprio campo gravitazionale senza che nessuna forza riesca a contrastarne la spinta. Perché si realizzi questo dominio incontrastato della contrazione gravitazionale è necessario che la massa iniziale del corpo sia davvero molto grande, almeno pari a qualche decina di volte la massa del Sole; e infatti i migliori candidati buchi neri finora individuati o sono residui di stelle particolarmente massicce, o addirittura sono mostri di massa pari a milioni di volte quella del Sole, nascosti nei nuclei di galassie attive.

Ma non potrebbero esistere buchi neri di massa molto più piccola? Gli esperti di relatività cominciarono a porsi seriamente questa domanda sul finire degli anni '60 e scoprirono che in effetti, nelle prime frazioni di secondo dopo il Big Bang, è possibile che nell'Universo si siano formati piccoli buchi neri dalla contrazione di regioni di alta densità; questi buchi neri primordiali dovrebbero essere ora sparsi nell'Universo e, se interagiscono in qualche modo con la materia ordinaria, dovrebbe essere possibile rivelarne la presenza.

Sollecitato da questa idea Stephen Hawking cominciò a studiare le proprietà quantistiche che questi piccoli buchi neri avrebbero dovuto avere, giungendo, nel 1974, alla scoperta del cosiddetto *processo di evaporazione* dei buchi neri. La causa di questo processo sta nelle strane proprietà che la meccanica quantistica attribuisce al vuoto. In seguito al principio di indeterminazione, infatti, il vuoto quantistico è popolato da particelle virtuali, cioè da coppie particella-antiparticella che esistono solo per tempi brevissimi e subito tornano ad annichilarsi l'una con l'altra, in un ribollire incessante. Nei pressi di un buco nero può succedere che l'intenso campo gravitazionale riesca a separare la coppia abbastanza a lungo perché una delle due particelle finisca catturata mentre l'altra sfugge all'attrazione fatale e comincia a esistere autonomamente come una particella reale.

Solo una decina tra le migliaia di gamma *burst* finora scoperti potrebbe essere il risultato dell'evaporazione di un buco nero primordiale. Gli altri hanno un'origine sicuramente diversa e il lavoro congiunto del satellite italiano BeppoSAX e del Telescopio Spaziale "Hubble" (HST) sta contribuendo a chiarirla. In questa immagine l'HST rivela che al 5 settembre è ancora presente una debole sorgente nella posizione in cui, il 28 febbraio, era apparso un GRB scoperto da BeppoSAX. A sinistra, la ripresa del campo; a destra, l'ingrandimento mostra la controparte ottica ("sorgente") all'interno di una nebulosità che è probabilmente una lontana galassia ("ospite"). Si rafforza con ciò l'ipotesi che i gamma *burst*, nella loro maggioranza, siano innescati dallo scontro-fusione di due stelle di neutroni in galassie a distanze cosmologiche. (*A. Fruchter; NASA*)

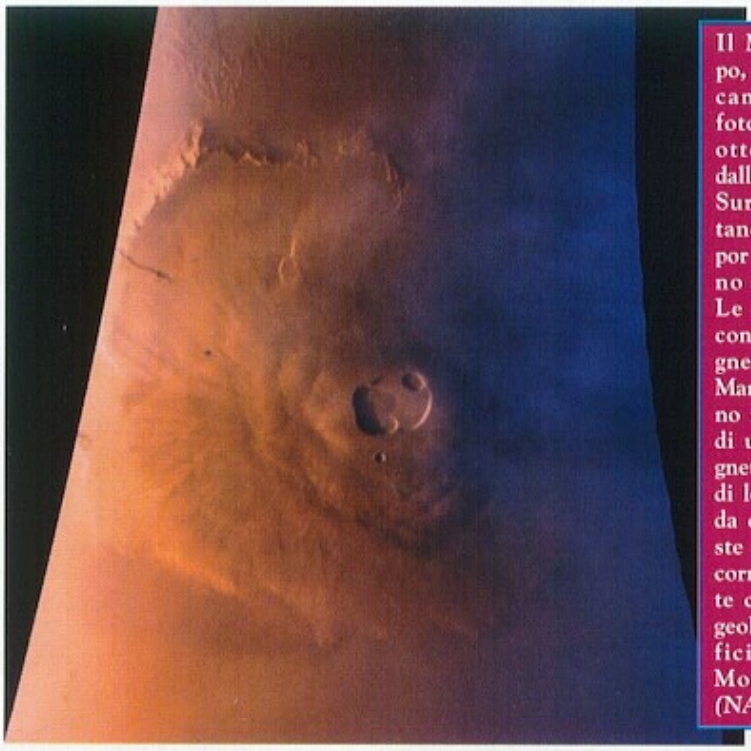
Il risultato di questo processo è che il buco nero sembra irraggiare verso l'esterno, come un corpo che si trovi a una certa temperatura, che risulta essere inversamente proporzionale alla massa del buco nero stesso. I buchi neri di taglia stellare o superiore non riescono di fatto ad irraggiare, perché le loro temperature risultano essere molto più basse di quella della radiazione di fondo cosmico (un buco nero di massa pari al Sole avrebbe, ad esempio, una temperatura di un millesimo di grado sopra lo zero assoluto), ma i buchi neri primordiali di piccola massa avrebbero temperature sufficientemente alte da irraggiare in modo efficiente, e in tal modo la loro massa continuerebbe a diminuire, portando a un ulteriore aumento della temperatura.

Alla fine del processo questi mini buchi neri, raggiungendo temperature altissime, dovrebbero esplodere in un lampo di particelle ed energia. Negli stessi anni in cui Hawking elaborava la sua fondamentale teoria, venivano scoperti in cielo i cosiddetti gamma *burst*: lampi di radiazione gamma di grande intensità e di breve durata, apparentemente non associati a nessuna sorgente nota, e fu immediato pensare che questi lampi potessero essere causati proprio dall'evaporazione di buchi neri primordiali.

Bastarono però le prime verifiche per spegnere gli entusiasmi, perché risultò subito chiaro che l'evoluzione temporale dei gamma *burst* registrati era incompatibile con i lampi di brevissima durata che ci si attendeva dall'evaporazione di un buco nero primordiale.

L'importanza che avrebbe la scoperta dell'evaporazione di un buco nero primordiale è però tale che le ricerche continuarono. In questi anni si è cercato di determinare quale possa essere la densità di buchi neri primordiali compatibile con altre osservazioni astrofisiche e si è arrivati a ritenere che deve essere piuttosto bassa. Si è inoltre cercato di migliorare i modelli che descrivono la loro evaporazione, nonostante le enormi difficoltà incontrate perché sappiamo troppo poco della fisica che si deve applicare in quelle condizioni estreme. Nel frattempo, anche lo studio dei gamma *burst* ha fatto grandi passi avanti, grazie soprattutto ai dati raccolti dal satellite GRO, che ne ha registrati diverse centinaia: vale quindi la pena di tornare a verificare se, tra i tanti osservati, non ve ne sia almeno qualcuno che potrebbe essere attribuito all'evaporazione di un buco nero primordiale.

I risultati di una ricerca di questo tipo sono stati pubblicati di recente (D.B.



Il Monte Olimpo, il più alto vulcano marziano, fotografato il 20 ottobre scorso dalla Mars Global Surveyor. Si notano nubi di vapor d'acqua attorno alla caldera. Le osservazioni condotte dal magnetometro della Mars Global hanno rivelato tracce di un campo magnetico a macchia di leopardo; resta da capire se queste macchie sono correlate con certe configurazioni geologiche superficiali, come il Monte Olimpo. (NASA)

Il monitoraggio del magnetismo marziano rappresenta un inatteso "bonus" per la politica portata avanti dalla NASA negli ultimi anni, che è riassunta nelle tre parole "*better, faster, cheaper*", cioè missioni con tempi di sviluppo rapidi, che utilizzino tecnologie dell'ultima generazione e che soprattutto costino poco. Infatti, per ridurre al minimo la quantità di propellente a bordo e quindi per soddisfare all'ultima condizione, la circolarizzazione dell'orbita a un'altezza di 380 km non avviene utilizzando i motori di bordo, ma sfruttando la decelerazione indotta dall'attrito con gli strati alti dell'atmosfera. Questa operazione di aerofrenaggio (*aerobraking*) ha fatto passare la sonda per diverse volte a un'altezza dalla superficie di Marte di soli 110 km, da cui è stato possibile rilevare almeno otto o nove macchie di magnetizzazione, ciascuna delle dimensioni di alcune centinaia di chilometri.

L'intensità magnetica che è stata registrata dalla Mars Global Surveyor si aggira costantemente attorno a valori mille volte più bassi rispetto al campo magnetico terrestre alla stessa altezza, ma molto superiori a quelli delle analoghe macchie magnetiche presenti sulla Luna. Sulla Terra, e forse anche su Marte, le anomalie magnetiche presenti sono resti del campo generato dal nucleo. Quando il magma si solidifica all'interno della crosta o sulla sua superficie, il campo magnetico al momento presente viene come congelato. Le anomalie di Marte sono probabilmente di maggiore intensità rispetto a quelle di altri corpi, come appunto la Luna, poiché il magma marziano potrebbe essere più ricco di magnetite, un minerale del ferro. Nel caso della Luna però l'origine delle anomalie magnetiche potrebbe anche essere ricercata nei giganteschi impatti che generarono nel lontano passato i "mari". E' stato provato infatti in esperimenti di laboratorio, in cui si sono effettuati impatti ad ipervelocità su rocce basaltiche, che attorno alla regione colpita si genera un debole campo magnetico permanente.

Sarà interessante adesso cercare di correlare i nuovi dati sul magnetismo di Marte con le configurazioni geologiche della superficie del pianeta per cercare di capire l'evoluzione del suo campo magnetico.

Le analisi preliminari infine mostrano già che alcune delle macchie magnetiche osservate presentano polarità opposte, per cui si potrebbe dedurre che, come sulla Terra, il campo magnetico di Marte abbia subito periodiche inversioni. Anche se l'interno del pianeta rosso risulta magneticamente morto, lo studio delle anomalie osservate potrà dare un notevole contributo alla ricostruzione delle prime fasi della sua storia geologica.

Mario Di Martino
Osservatorio Astronomico di Torino

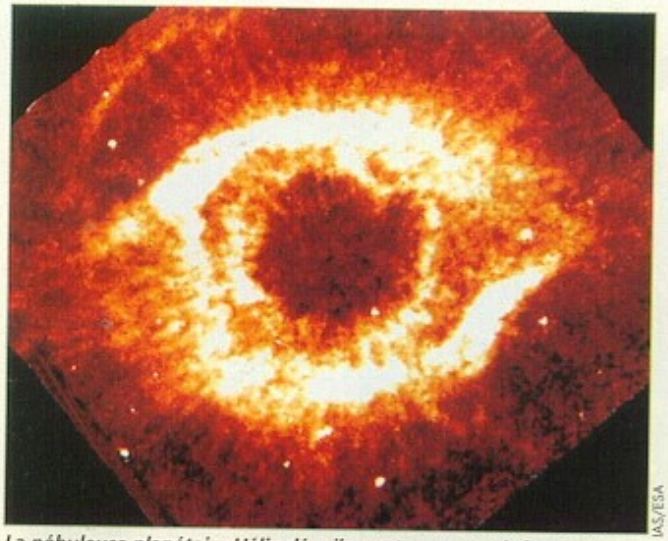
Aldebaran e la Luna

Una settantina di astrofili si sono trovati nei pressi di Bologna il 15 novembre per l'occultazione radente di alfa Tauri.

GIÀ NELL'AGOSTO DEL 1992 eravamo in tanti, provenienti un po' da tutta Europa, per seguire l'occultazione lunare radente della stella *mu* Geminorum, di magnitudine visuale 2,8. Allora la coincidenza dell'evento con l'undicesimo European Symposium on Occultation Projects, tenutosi a Castel Gandolfo, aveva decisamente favorito la partecipazione degli astrofili interessati a questo tipo di osservazioni. Ma lo scorso 15 novembre non vi erano altri motivi se non il desiderio di compiere un'osservazione utile e spettacolare, oltre che non frequente; con questo spirito ci siamo ritrovati a Castel S. Pietro, caratteristica cittadina a sud di Bologna, e questa volta l'occultazione radente interessava Aldebaran, che con le sue 0,8 magnitudini visuali è tra le più brillanti stelle occultabili dal nostro satellite naturale.

Così, grazie all'efficace organizzazione allestita da Roberto Di Luca, Carlo Frisoni e da altri membri della Associazione Astrofili Bolognesi, si sono dati appuntamento astrofili provenienti da Milano, Napoli, Torino, Treviso, ma anche da Monaco e Stoccarda, tutti lì distribuiti lungo poco più di 7 km a ridosso della linea di radenza teorica, dalla quale sarebbe stato possibile vedere la stella sparire e ricomparire più volte attraverso le frastagliature del bordo lunare nello spazio di pochi minuti.

Difficilmente Copernico avrebbe potuto immaginare che esattamente cinquecento anni dopo la sua famosa osservazione dell'occultazione lunare di Aldebaran, compiuta a Bologna il 9 marzo 1497, ben 72 astrofili (tra i quali 16 provenienti dalla Germania e 6 dal Belgio), muniti di piccoli ma efficaci telescopi, si sarebbero organizzati in trenta differenti postazioni per seguire quello stesso fenomeno. E se il grande astronomo polacco dovette accontentarsi di un rudimentale strumento che con apposite mire consentiva la misurazione dell'altezza di un astro in cielo, questa volta all'appuntamento erano



IAS/ESA

La nébuleuse planétaire Hélix dévoile sa structure en infrarouge.

devraient luire en infrarouge, sont étrangement absentes. Alors que l'anneau brillant correspond en fait à de l'hydrogène moléculaire. Selon Pierre Cox, de l'Institut d'astrophysique d'Orsay, les poussières ont été détruites par l'intense rayonnement UV émis par la naine blanche qui luit au milieu, mais qui est invisible à ces longueurs d'onde. ■

système solaire

Première alerte pour Mars Global Surveyor

La mission avait bien commencé avec l'arrivée de la sonde autour de Mars mi-septembre. Mais les ingénieurs du Jet Propulsion Laboratory ont dû déchanter le 6 octobre : l'un des deux panneaux solaires (incomplètement déployé depuis le lancement) de Mars Global Surveyor a changé de position. Ils ont en outre constaté lors de ce passage que l'atmosphère martienne se révélait deux fois plus dense que prévu. Ce déplacement intempestif les a obligés à interrompre les manœuvres de freinage aérodynamique dans la haute atmosphère de la planète. L'altitude du périastre a été relevée de 121 à 170 km et Mars Global Surveyor laissée sur cette orbite pour plusieurs semaines. Les manœuvres d'aérofreinage ont repris début novembre, mais elles pourraient prendre près d'un an. Conséquence, la sonde n'atteindra probablement pas la trajectoire héliosynchrone prévue. La Nasa étudie de nouvelles orbites afin de ne pas compromettre la mission ■

EOS repart du bon pied

Le projet d'observation de la Terre de la Nasa, dont les coûts ont été revus pour tenir dans une enveloppe raisonnable, est maintenant sur les rails. Avec dix-huit mois de retard, le premier d'une série de satellites capables de nous apporter une vision globale de la Terre, EOS-AM1 (Earth Observing System), sera lancé en juin 1998 par une fusée Atlas-Centaur IIAS. Placé sur une orbite polaire, EOS-AM1 sera équipé de cinq instruments de mesure fonctionnant simultanément pour étudier à la fois les terres émergées, les océans et l'atmosphère. Le projet EOS d'un coût de six milliards de dollars, dont deux milliards consacrés à la banque de données Eosdis, se poursuivra par le lancement du satellite PM1 en 2000 qui sera associé au satellite "chimique" Chem-1 en décembre 2002. Une fois achevé, ce réseau satellitaire fournira un téraoctet (mille milliards d'octets) de données par jour, délivrant en six mois l'équivalent de vingt-cinq ans d'archives de la Nasa. ■

Seastar, première image

Seawifs/Nasa/GSFC

Seastar fournit une cartographie inédite des océans, des continents et de la réserve écologique planétaire.

Depuis le 23 septembre dernier, le nouveau satellite américain Seastar envoie des images à trois cents scientifiques dans plus de dix-huit pays. Grâce à son instrument SeaWIFS, il transmet des photographies couleurs à haute résolution de tous les océans du globe — l'une de ses principales tâches étant d'évaluer la concentration en phytoplancton — mais aussi des terres émergées. Ainsi, outre des informations sur la biosphère et la dynamique des climats, les données transmises par Seastar vont servir à la gestion écologique des zones côtières et des ressources de la pêche. ■

Les géantes ont des vapeurs

ESA

Selon ISO, il pleut de la vapeur d'eau sur les planètes géantes (ici, Jupiter vue en infrarouge).

De la vapeur d'eau flotte dans la haute atmosphère d'Uranus, de Saturne et de Neptune. Emmanuel Lellouch de l'observatoire de Meudon et ses collaborateurs ont abouti à cette conclusion grâce aux observations en infrarouge lointain effectuées par ISO d'octobre 1996 à juin 1997. Or cette vapeur ne peut pas provenir de la "surface" des planètes géantes car elle se transformerait en nuages de glace lors de sa traversée de la basse atmosphère. Les astrophysiciens pensent donc qu'elle a une origine externe et qu'elle serait issue de glaces provenant soit des anneaux et satellites qui entou-

Mike Nelson/AFP

Cette pièce spécialement aménagée pour la mission Mars Pathfinder a été baptisé "le bac à sable". Durant des semaines, les spécialistes de robotique y ont testé les comportements de Sojourner avant son départ pour Mars.

la première sonde à survoler un autre des mondes du Système solaire. Mariner 10 sera quant à elle la première à utiliser la technique du rebond gravitationnel, profitant d'un petit coup de pouce de Vénus pour filer vers Mercure. Au milieu des années 70, les deux sondes Viking s'envoleront pour conquérir la planète rouge. Deux ans plus tard, ce sera au tour des deux Voyager de partir dévoiler l'environnement des planètes géantes. *"Durant les années 70, la philosophie était de tout doubler*, se souvient Haynes. *Pour un coût supérieur à celui d'un lancement simple, certes, mais avec un gros avantage : vous ne risquiez pas d'être bloqué si l'une des deux sondes venait à défaillir !"* Mais à l'approche des années 80, les budgets de la Nasa ne permettront plus de s'offrir ce luxe. Les sondes qui naîtront désormais sur les planches à dessin du JPL auront perdu leur alter ego. Telle Magellan, lancée le 5 mai 1989 par la navette, et qui révélera dans le détail l'enfer vénusien. Ou Galileo, qui partira cinq mois plus tard vers le système de Jupiter[2], n'augurant pas que du meilleur pour le Laboratoire…

Approuvé en effet dès 1978, le programme Galileo va subir de multiples reports de lancement, suite à des multiples défaillances de navettes, dont la dramatique explosion, en 1986, de Challenger. Quand les ingénieurs du JPL voient enfin la sonde s'envoler fin 1989, c'est pour constater que son antenne à grand gain ne se déploie pas comme prévu, et que le nombre de clichés qu'elle est censée transmettre va cruellement s'en ressentir.

D'autre part, alors qu'ils développent des trésors d'ingéniosité pour tenter de "maximiser" les données fournies par la petite antenne à faible gain, la Nasa, elle, affronte les foudres grandissantes du Congrès, où des voix s'élèvent pour réclamer l'arrêt du financement de ces projets grandioses. Après tout, disent-elles, un échec, et ce sont des milliards de dollars qui s'envolent en fumée, et des équipes entières sur le carreau. Or c'est précisément ce qu'il adviendra en 1993, lorsque la Nasa perdra le contrôle de la sonde Mars Observer peu avant qu'elle n'amorce le freinage qui devait la placer sur une orbite martienne. Cette catastrophe, abondamment relayée par les médias, sonnera le glas des grosses missions.

"L'avantage des Voyager, Galileo et autres Cassini, c'est qu'elles sont bardées d'une tonne d'instruments scientifiques et dotées d'infinies possibilités, remarque Norman Haynes. *Il ne vous reste plus qu'à les envoyer vers leur cible. À partir de là, vous pouvez tout faire… Elles exigent un investissement de travail incroyable, mais le bénéfice est énorme."* Pour comparaison, il faudra pas moins de trois sondes nouvelle génération — en l'occurrence, Mars Global Surveyor, l'orbiteur prévu pour 1998 et celui de 2001 — pour rivaliser avec les instruments de la défunte Mars Observer. *"Leur désavantage*, poursuit Haynes, *c'est que la plupart n'ont eu droit qu'à un seul lancement, ce qui vous coince en cas d'échec. En outre, lorsque vous envoyez une sonde comme Galileo vers Jupiter, vous savez à coup sûr que vous ne réitérerez pas l'expérience deux ans plus tard. Il vous faudra attendre quinze à vingt ans…"*

La nouvelle philosophie chère à Daniel Goldin, elle, n'a pas ces contraintes. Mais que Mars Pathfinder ait raté son rocambolesque atterrissage, emmaillotée dans ses ballons, et la devise du "plus petit, plus rapide et moins cher" aurait été fortement ébranlée, murmurent certains. Au contraire, elle est sortie renforcée du succès de la mission. *"Mars Pathfinder a réellement prouvé que les programmes d'exploration planétaire avaient toujours de l'avenir*, explique Ed Stone. *Un avenir autre que celui d'antan — l'heure n'est plus à privilégier un mode d'exploration du Système solaire. Nous exploitons désormais une foule de nouvelles approches, toutes différentes, et qui s'accordent mieux avec la science que nous tentons de faire. Mais un avenir viable, et terriblement excitant."*

"Nous avons du pain sur la planche, conclut Haynes. *Pour les dix années à venir, quelque chose comme vingt-cinq tirs sont prévus sur nos tablettes ! C'est presque exactement ce que nous devions fournir dans les années 60. Pour nous, en somme, c'est un retour vers le futur…"* ■

(1) En 1997, le JPL s'est vu attribuer par la Nasa un budget de 1.1 milliard de dollars.

(2) À l'époque, le JPL prit également part au projet Ulysse, la sonde destinée à l'étude du Soleil que l'Agence spatiale européenne lança en 1990.

XANADU
11.97

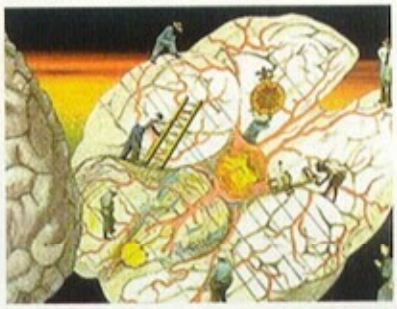
Mañana

Construye tu porvenir

pero mira a las estrellas. Ya lo dijo Kepler, «el destino influye, no determina». Los estudios astrológicos marcan tendencias para encauzar la vida. Es mejor seguir la corriente que luchar contra ella. Los partidarios de la libertad creen capaz al hombre de superar el sino marcado.

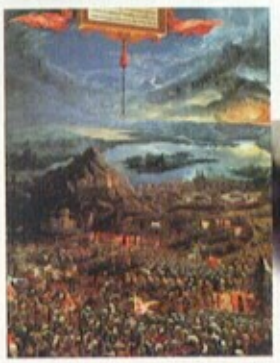
Seguridad por

control mental. La experimentación con las ondas beta que nuestro cerebro emite y que, hasta ahora, sólo habían sido estudiadas para aclarar la telepatía o la telekinesia, podrían estar en la base de un cambio radical dentro de la vivienda. La captación de estas ondas determinaría la activación de diversos aparatos a distancia, fundamentalmente los relacionados con la seguridad. Un simple '*chip*' en el cerebro podría cerrar herméticamente todas las puertas exteriores de la vivienda o abrirlas en caso de necesidad.



Batallas

virtuales, guerras del año 2000. El desarrollo de los superordenadores convierte la guerra en un juego electrónico y su evolución natural hace imposible la actividad guerrera tradicional. Actualmente es factible determinar, como en un tablero de ajedrez, las posibilidades marcadas por los estrategas. Esto se podría concretar en la nueva concepción de batalla virtual: los soldados de ambos bandos, sin moverse de su campamento, serían introducidos mentalmente en un escenario virtual donde podrían enfrentarse sin dañar a terceros.



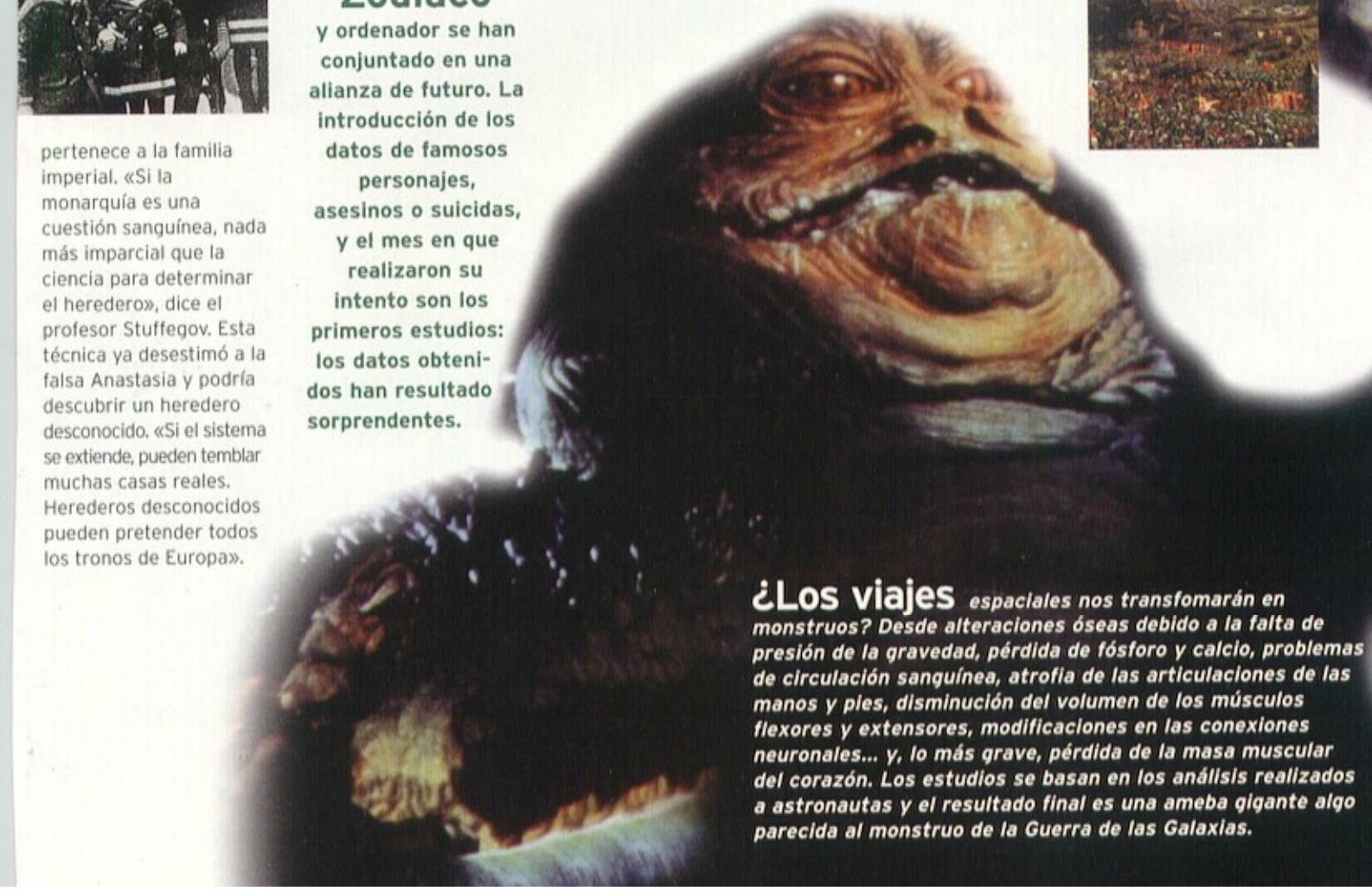
ADN Romanov

¿A quién pertenece el trono imperial ruso? ¿Dónde reposarán los restos de la familia imperial asesinada? ¿Será el heredero el joven príncipe Bragatión, actualmente en Madrid? Una hipótesis que tiene en cuenta la desaparición de dos cadáveres de aquella masacre ha sido articulada por la facultad de biología de Moscú: cualquier ruso puede ser el heredero si la estructura de su ADN demuestra que

pertenece a la familia imperial. «Si la monarquía es una cuestión sanguínea, nada más imparcial que la ciencia para determinar el heredero», dice el profesor Stuffegov. Esta técnica ya desestimó a la falsa Anastasia y podría descubrir un heredero desconocido. «Si el sistema se extiende, pueden temblar muchas casas reales. Herederos desconocidos pueden pretender todos los tronos de Europa».

Zodiaco

y ordenador se han conjuntado en una alianza de futuro. La introducción de los datos de famosos personajes, asesinos o suicidas, y el mes en que realizaron su intento son los primeros estudios: los datos obtenidos han resultado sorprendentes.



¿Los viajes

espaciales nos transfomarán en monstruos? Desde alteraciones óseas debido a la falta de presión de la gravedad, pérdida de fósforo y calcio, problemas de circulación sanguínea, atrofia de las articulaciones de las manos y pies, disminución del volumen de los músculos flexores y extensores, modificaciones en las conexiones neuronales... y, lo más grave, pérdida de la masa muscular del corazón. Los estudios se basan en los análisis realizados a astronautas y el resultado final es una ameba gigante algo parecida al monstruo de la Guerra de las Galaxias.

ing gas and dust in the plane of the Milky Way that, at optical wavelengths, it is completely invisible. However, the longer wavelengths of the infrared make it through, thereby pulling away the curtain that hides our central regions. But it is only this decade that has seen the development of infrared imagers which make it possible to take pictures at a resolution comparable to the visible.

By using these devices on large telescopes it has proved possible to take high quality infrared pictures of the luminous stars that surround the centre. And by doing this regularly then the motions across the sky (proper motions) of these stars can be measured.

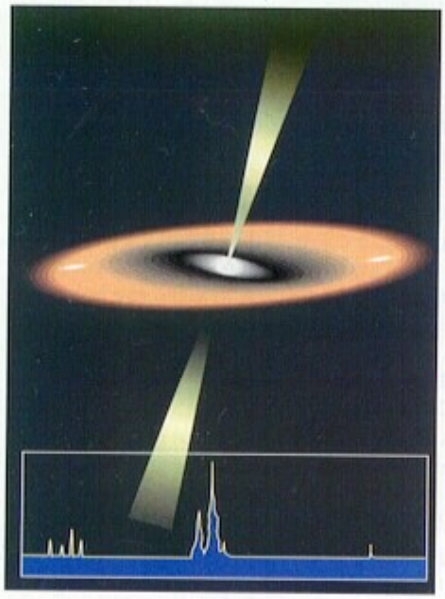
The exciting result of these observations was the discovery that these velocities are both very high and consistent with these stars orbiting around a very heavy, but unseen mass. The velocities are much higher closest to the centre (in exactly the same way that the innermost planet Mercury orbits the Sun with the highest velocity). Indeed, the velocities of these stars can be explained extremely well with a central mass of 2.6 million suns.

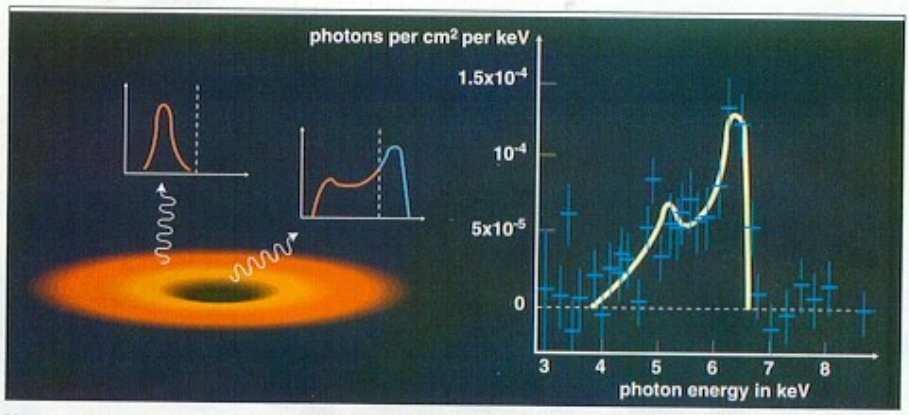
Active galactic nuclei

In the relatively nearby Virgo cluster of galaxies lies the giant elliptical galaxy M87, renowned for years for the optical and radio jet emanating from its centre. And with a redshift of only 0.0043 it was a natural target for the Hubble Space Telescope since an angular scale of one arcsecond corresponds to a linear dimension of two hundred lightyears.

The HST images reveal detail in the jet with breathtaking clarity, but more importantly HST was able to obtain spectra (with the Faint Object Spectrograph) of the apparent disc around the central region. Not surprisingly these revealed high velocity material that is entirely consistent with it being in a disc orbiting the unseen compact object. And to achieve velocities this high (750km/s) at this distance from the nucleus requires extremely high masses (2.4 billion solar masses contained within the central 0.1 arcsecond).

Distribution of water masers and their velocities across the central regions of NGC4258. AN graphic by Mark McLellan after Moran *et al.*





X-ray spectra of MCG-6-30-15 taken with the Japanese ASCA satellite (by Tanaka *et al*). The underlying model is that of emission from the region around the event horizon which is significantly affected by gravitational redshifts to produce the complex profile seen. AN graphic by Mark McLellan after Y. Tanaka *et al.*

But perhaps the most beautiful example of orbital motion around a supermassive black hole in an active glactic nucleus (AGN) was afforded by the water masers in NGC4258. These interstellar clouds of ordinary water molecules form parts of a large (about one lightyear across) warped accretion disc that is seen almost edge on.

The water molecules face the glare of the intense central radiation source, which causes them to become excited and radiate at a very particular frequency (22 GHz, i.e. microwaves). At the right densities, these microwaves stimulate other water molecules to radiate as well, producing a 'maser' effect within the clouds (exactly the same as lasers, but at microwave frequencies rather than with visible light). This effect is far more likely to be noticeable only in edge-on galaxies because the maser process is most effective in the plane of the disc.

At the distance of NGC4258 (over 20 million lightyears) these clouds are only a few milliarcseconds from the nucleus. Such angular resolution is a hundred times smaller than that achievable optically by HST, but linked radio telescopes performing ground-based VLBI (very-long baseline interferometry) have allowed the clouds to be resolved and their velocities measured (from the Doppler effect on their maser emission frequency). These velocities are beautifully arranged on each side of the nucleus so that the innermost clouds are moving fastest, ordered in the same way as the velocities of the planets around the Sun.

Results show velocities that would be expected if the molecular clouds were orbiting a central object of 36 million solar masses. The fit is remarkably good, and represents the best evidence yet for an extremely massive, but extremely compact object. The object must be contained within a region much less than a lightyear across (the location of the inner water cloud), and that is 60 times smaller than the disc observed by HST in M87. Interestingly, NGC4258 also displays radio and optical jets which are perpendicular to this disc, exactly as expected.

ASCA results

The Japanese X-ray spectroscopy satellite ASCA has viewed the blazar MCG-6-30-15. The X-ray emission from the blazar requires extremely high temperatures (millions of degrees) and so must be arising in the inner disc, close to the event horizon, where we can hope to see some of the effects of a central massive black hole.

The X-ray spectrum obtained by ASCA (using a CCD for the first time as an X-ray detector in a satellite) revealed the presence of a strong emission line due to iron. But this is not iron in the form you normally meet it. At millions of degrees it has been stripped of all its electrons except one (which makes it just like a rather heavy hydrogen atom) and emits an emission line at 6.7keV (thousands of electron-Volts).

With ASCA's far superior resolution (at this sensitivity) to any instrument flown before, it was clear from the line profile that it was highly perturbed, with a pronounced 'horn' on the blue (high energy) side and an extensive tail on the red side.

The double peak was easily explained: imagine looking at an accretion disc at an oblique angle, one half will be rotating towards you (blueshifted) and the other half away (redshifted), hence the two peaks. But special relativity tells us that the blueshifted component will be boosted (and hence brighter), and general relativity shows that if there is a massive black hole in the centre of the disc then there will be a gravitational redshift of the whole profile (i.e. it is all bodily shifted towards the red). This is exactly the effect seen in MCG-6-30-15, showing that X-ray spectroscopy may provide us with the long-sought signature of the presence of a black hole.

Professor Phil Charles is head of astrophysics at the University of Oxford.

Mars Approaching Opposition

When it comes to visible surface markings, Mars has the other planets beat. Although the globe of Saturn appears twice as wide as Mars's this month, the rusty colored 9"-diameter disk displays far more detail than the nearly featureless cloud bands of Saturn.

Mars is only two months from its opposition in April. That's when it will reach its greatest apparent diameter (16") and be visible all night. This will be our best view of Mars since 1990.

As February opens, Mars rises at midnight. The planet's bright, red color is easily spotted in the dim stars of Virgo. Mars lies just to the east of Virgo's brightest star, Spica. Watch as the separation between the two increases as the month progresses.

The more often you look at Mars through a telescope, the easier it is to see tiny details on the martian surface. So hone those skills. Besides watching the planet's ice caps gradually change size, try to identify the dark markings and check the pale yellow areas for featureless lighter patches — signs that a dust storm is in progress. The trick is to get up early or stay awake until the early morning hours. Mars reaches the meridian at about 5 A.M. local time.

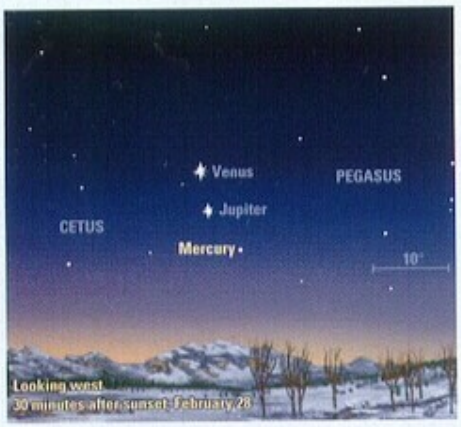
Donald C. Parker

While you're flexing your detection abilities, note the phase of the moon as it passes by on the morning of February 6 — last quarter. Next month, the moon will be a bit fatter when it passes Mars.

Solar System Boogie

Mercury has a great display late this month. Certainly the Venus/Jupiter conjunction will outshine the speedy innermost planet, but the dazzling duo will actually help in the search for elusive Mercury.

On February 23, the closest approach of Venus and Jupiter, Mercury will be a modest naked-eye sight 4° above the western horizon one hour after sunset. The planet shines at magnitude –1.0 in deep blue twilight. A view through the telescope shows a small, gibbous phase, 77 percent lit.



By February 28, Mercury will be halfway between Jupiter and the horizon. It forms a nearly evenly spaced but crooked line with the other two planets. At this point, Mercury is starting to lose some of its brilliance. Though its apparent disk size is growing, the planet's phase is shrinking. Mercury is moving closer to the half-moon or one-quarter phase. On February 28, a 6.8" disk will hold a 58-percent-lit phase. One week later, Mercury is easily spotted 5° to Jupiter's right (north).

Mercury is also at perihelion (closest point to the sun) on February 28. Can you determine its orbital position relative to Earth, Jupiter, Saturn, and the sun by what is seen in the sky?

Asteroid 10 Hygiea reaches opposition this month as well. Hygiea is at magnitude 9.7 in Leo on February 15. Although faint, an ideal opportunity to spot the asteroid occurs a few days before and after February 23. On that date, Hygiea passes close to the 4th-magnitude star Omicron Leonis. Plot the field of view for three nights. The asteroid will reveal itself by its motion with respect to the star.

Rising with Leo is Ursa Major the Great Bear. Its bright asterism, the Big Dipper, dominates the northeastern sky. This large, well-known group of stars holds many deep-sky gems. The Owl Nebula (M97) can be found here, along with the fine naked-eye double Mizar and Alcor. Fine galaxies such as M81, M82, and the beautiful face-on spiral M101 are here as well. To top things off, the constellation is visible all night.

An annular eclipse of the sun occurs across the Indian Ocean and Australia on February 16. Although the moon exactly lines up with the sun, it is also near its farthest orbital point from Earth. This makes the moon's disk a bit too small to block out all of the sun's disk. At mid-eclipse, a ring, or annulus, is visible around the dark limb of the moon — hence the name annular eclipse. Eye protection is required for viewing all phases of the eclipse. The central track passes north of the Australian city of Perth. A

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

New wave of Mars exploration begins

A pair of new Mars probes signal the start of an ambitious series of missions that will culminate with the return to earth of soil samples. By William Harwood

Following on the heels of the wildly successful Mars Pathfinder, NASA has launched the second in a series of low-budget martian landers, this one equipped with a trench-digging robot arm, to search for subsurface water near the south pole and to help pave the way for an eventual sample return mission.

"One of the most compelling questions that NASA's space programme is determined to answer is whether life on Earth is unique or whether it is a cosmic imperative," said Ed Weiler, NASA's associate administrator for space science. "If you want to look for life, either fossilized life or existing life, you have to follow the water."

Launched January 3 from the Cape Canaveral Air Station in Florida, the 290-kilogram (639-pound) Mars Polar Lander is scheduled to slam into the red planet's tenuous atmosphere on December 3, using a parachute and small retro rockets to make a pinpoint touchdown in the planet's south polar region.

Technicians prepare the Mars Polar lander for launch. Photo: NASA/KSC.

The Mars Climate Orbiter lifts off from Cape Canaveral Air Station on December 11, 1998, starting a new wave in exploration of the Red Planet. Photo: NASA/KSC.

But first, two small penetrators will be released less than five minutes before atmospheric entry that will free fall to the surface, hitting the ground at 180 metres per second (400 mph) and burying small water/carbon dioxide sensors up to one metre (three feet) beneath the surface 100 kilometres (60 miles) from the main lander's touchdown point. Data from the penetrators will be radioed back to Earth via the Mars Global Surveyor spacecraft currently in orbit around Mars.

But the Mars Polar Lander is the star of the show. Instead of a rover like Pathfinder's Sojourner, the polar lander is equipped with a two-metre (6.5-foot) robot arm equipped with a digging scoop, a camera and a temperature sensor.

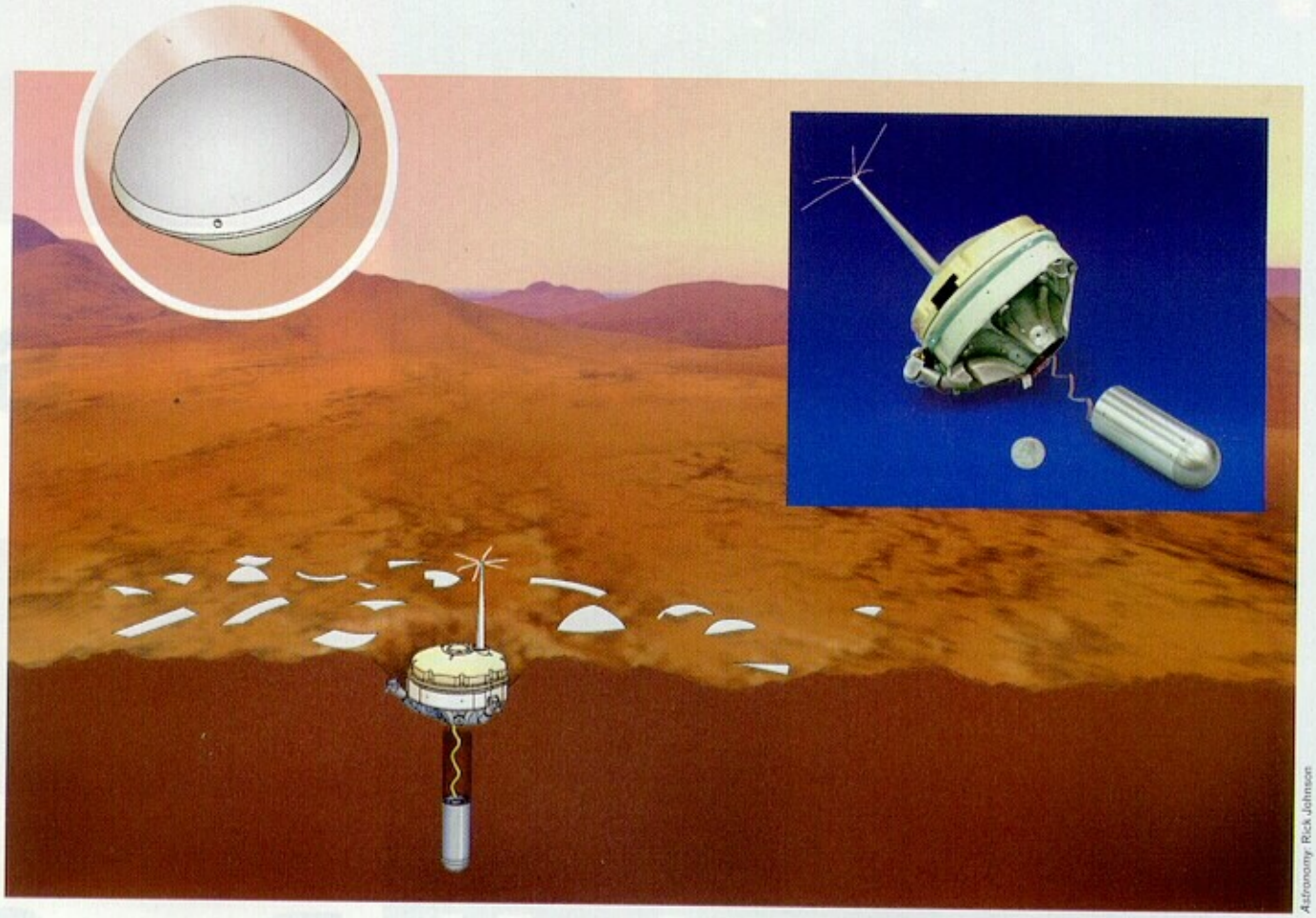
The arm will be used to dig shallow trenches near the lander a few centimetres (inches) deep. Along with examining the walls of the trenches for signs of layering, small soil samples will be scooped up and placed in an instrument called the thermal and evolved gas analyzer.

Solar-powered toaster-like coils will heat the soil to 1,027 degrees Centigrade (1,880 degrees Fahrenheit) and a tunable laser will be used to analyze the constituents of any resulting gas to look for traces of water or carbon dioxide.

A suite of U.S.-Russian meteorology instruments will monitor clouds, winds and temperatures at the landing site on a daily basis and a small microphone will listen to whatever sounds the gentle martian wind might make.

"I hope this one finds some water," Weiler said. "We've been talking about the possibility of water on Mars for eons and this thing really has a good chance of finding it, showing that it's really there – in the form of ice, of course."

The Mars Polar Lander will relay much of its data back to Earth via the Mars Climate Orbiter, a follow-on to the Mars Global Surveyor, launched December 11, 1998, from Cape Canaveral Air Station. As its name implies, the climate orbiter will be used primarily to study the martian atmosphere and to take wide-angle panoramic pictures of the surface.



Astronomy: Rick Johnson

When Mars Polar Lander enters Mars's atmosphere, it will drop two 5.5-pound penetrators (upper right). The Deep Space 2 probes will free-fall inside basketball-sized aeroshells (upper left), which will slam into the surface at about 450 miles per hour and bury the penetrators 3 feet deep.

Surveyor program is very advanced, and phenomenally inexpensive," says Euler. The entire cost of the Mars '98 orbiter and lander development is $184 million, approximately the same as the Pathfinder lander alone when inflation is taken into account.

Future Expeditions

While Mars Climate Orbiter and Mars Polar Lander open new doorways into the martian past, other explorers will be readied for the next launch windows, which occur every 26 months. NASA's current plans call for an orbiter and lander to launch in 2001 and landers in 2003 and 2005. The 2001 orbiter will map element and mineral deposits across the globe, detecting areas where water may still be preserved near the surface. Another instrument will use infrared spectrometry to search the planet for future high-priority landing sites.

The 2001 lander will carry a sensor that measures the radiation threat to future human explorers. It will also analyze surface dust for acidity, electrical conductivity, and toxic chemicals — potential hazards to astronauts. Another experiment will attempt to manufacture oxygen from the martian atmosphere to see if it can be "mined" for propellants for future manned missions. The lander will bring along a rover that's virtually an identical twin of Mars Pathfinder's Sojourner.

As currently conceived, the 2003 lander will include the rover Athena, under development at Cornell University and JPL. This rugged six-wheeler will be a much larger and more sophisticated version of Sojourner. Athena will range up to 1,000 feet (300 meters) from the lander, collecting samples and drilling into rocks. Specimens will be analyzed on site, and some will be stored for possible return to Earth. While Pathfinder's vehicle was designed for a seven-day stint, Athena may last a full year, storing up to 91 rock and 13 soil samples. A microscopic imager will reveal details in rocks and soil. "Athena is a huge jump over the Sojourner-class rovers," says Cornell planetary scientist Jim Bell.

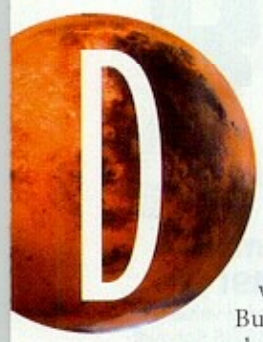
While NASA has no plans for a 2003 orbiter, the European Space Agency has recently approved funding for an ambitious 2003 orbiter called Mars Express. NASA, working with Italy's space agency, may provide a radar system to look for subsurface water. One of several European scientific groups may provide a small lander to accompany the orbiter.

The 2005 mission brings the ultimate payoff: the launch of a sample-return mission. As currently conceived, samples from the 2003 rover and a 2005 Athena-class rover will be launched into Mars orbit, where they will be collected by a French-built orbiter and then returned to Earth in 2008. With samples in hand and half a dozen missions under their belts, scientists hope to finally answer the question of what happened to the martian climate and what it means to us on this fragile blue world.

Michael Carroll frequently contributes articles and paintings to Astronomy. *His children's book about the planets,* Spinning Worlds, *can be ordered from his website at www.power-online.net/~spaceart.*

Divining on Mars

NASA is launching a martian orbiter and lander to find out what happened to the Red Planet's warmer and wetter climate.

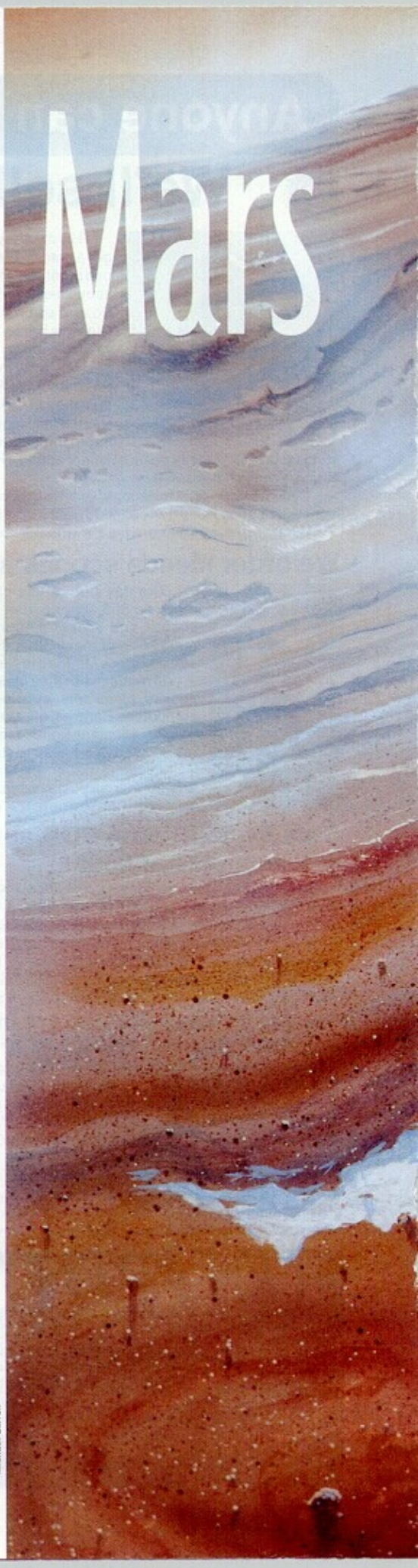


by Michael Carroll

DESPITE OUR BEST PRODDINGS, PHOTOS, DIGGINGS, AND rovings, Mars tenaciously clings to some of the greatest mysteries in planetary science. Since 1971, spacecraft have radioed back thousands of images that hint at a Mars far wetter and warmer than the parched world we see today. But these images leave many questions unanswered: How much water flowed across the surface of ancient Mars? Where did the water go? Why did Mars's climate change? Could the same thing happen to our own world?

To investigate the current martian climate and the puzzling history of climate change, NASA is launching the next pair of missions to the Red Planet: Mars Climate Orbiter and Mars Polar Lander. These two missions, collectively known as Mars Surveyor '98, follow closely on the heels of Mars Pathfinder and Mars Global Surveyor, which represented the first shots in NASA's ongoing "faster, better, cheaper" Mars exploration program.

At press time, Mars Climate Orbiter was scheduled to blast off a Kennedy Space Center launch pad on December 10, 1998, and arrive at Mars in September 1999. Mars Polar Lander was slated for a January 3, 1999, liftoff. After an 11-month cruise, it will touch down near the martian south pole in December 1999, using parachutes and braking thrusters to slow its final descent. Just before entering the atmosphere, the lander will drop two instrument-laden penetrators, which will crash-land onto the martian surface at separate locations approximately 60 miles (100 km) north of the lander.



Michael Carroll

NASA's next Mars lander will touch down near the south pole in early December 1999, when it's late spring in Mars's southern hemisphere. The lander carries a 6.6-foot-long robotic arm, which will dig into the soil to look for water. The lander should function for three months before the batteries freeze.

Where's the Water?

When they reach their destination, Mars Climate Orbiter and Mars Polar Lander will find a desolate planet whose surface is drier than the driest deserts on Earth. Mars's thin air doesn't supply enough pressure to support liquid water, which boils away almost instantly into the salmon-colored sky. Rivers have not flowed on Mars, nor have rains fallen there, for billions of years.

But Mars wasn't always such a dry place. Orbital photos from the Mariner 9 and Viking 1 and 2 missions of the 1970s revealed branching canyon systems and large, braided channels that closely resemble terrestrial river valley networks and flood channels. Planetary scientists almost unanimously agree that liquid water carved these martian canyons billions of years ago, meaning the Red Planet must have once had a thicker carbon dioxide-rich atmosphere that warmed the surface.

Mars Pathfinder and Mars Global Surveyor have added support to this picture. Pathfinder photographed stacked boulders, which were almost certainly deposited by rampaging flood waters. Mars Global Surveyor's high-resolution camera has imaged river-like gorges, layered sediments that may be related to standing water, and possibly even dry lake beds. Its infrared spectrometer has discovered the first clear evidence of an ancient hydrothermal system, implying that stable water remained at or near the surface for long periods of time early in martian history.

But perhaps Mars Global Surveyor's most dramatic result has come from the laser altimeter, which shows that the plains covering most of Mars's northern hemisphere are flatter than Kansas for thousands upon thousands of miles. "These broad expanses could be the long hypothesized ocean, covered over with sand dunes and lava flows," says Jeffrey Kargel of the United States Geological Survey in Flagstaff, Arizona. "What I'm most excited about is the possibility that the ocean is still there beneath the surface, either an ocean of frozen water or an ocean of mud."

Such an ocean would be an incredible natural resource for future human explorers, and it could imply past or even present life on Mars. But scientists still don't know if such an ocean ever existed, or if it did, how much water it contained. The water has vanished from the surface, and why it disappeared is one of planetary science's most profound mysteries. The amount of water detected in Mars's atmosphere and polar caps is nowhere near enough to explain the variety of geological features. Some of Mars's original water may have escaped into space, but much of it could still be there — locked up as ice in the crust.

A Mars Weather Satellite

The Mars Surveyor '98 missions were designed to address these questions. Mars Climate Orbiter's role is to monitor Mars's weather on a daily basis for a full martian year — equivalent to almost two full Earth years. The orbiter will also provide a communications link between Earth, Mars Polar Lander, and future surface robots.

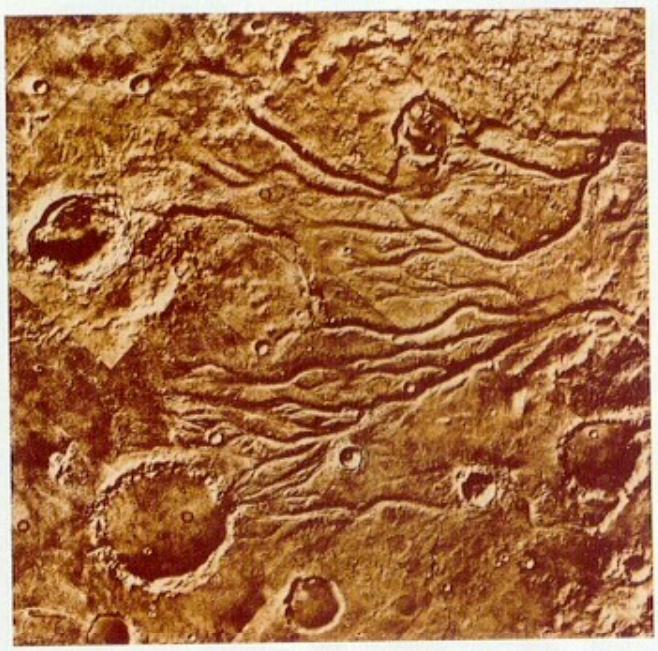
The spacecraft carries a spare of one of the instruments aboard NASA's ill-fated 1993 Mars Observer mission, the Pressure Modulator Infrared Radiometer (PMIRR). This instrument records the amount of dust and the temperature in the atmosphere as a function of altitude. The amount of airborne dust controls how much solar heat is absorbed by the atmosphere. The warmer the atmosphere, the more water vapor it can hold. Combining these results with data about humidity and water-ice clouds, researchers hope to nail down the present climate picture and better understand how water and carbon dioxide shuttle back and forth between the atmosphere and the polar regions over the course of a seasonal cycle.

The orbiter also carries an imaging system built by Malin Space Science Systems of San Diego, California, the company founded by geologist Michael Malin that is bringing us the

This Viking image shows a canyon that probably formed when subsurface ice suddenly melted and gushed to the surface in a torrential flood.

NASA/JPL

These branching valley networks, seen in a Viking 1 orbiter image, were almost certainly carved by running water billions of years ago.

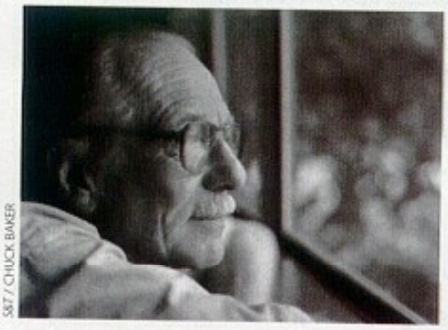


NASA/JPL

A Death in the Family

I once asked a visiting Soviet astronomer about the fortunes of a Dr. X, his countryman who I'd met in Prague years before. I described him as wonderfully bright and ambitious, and wondered why he'd dropped out of sight. The deadpan answer was, "Perhaps he was *too* ambitious."

Maybe that's what went wrong with *Earth*, a magazine aimed at educating us about how our planet works. When it first appeared, the noise on the street said its objective was to be a competitor to *National Geographic*. Indeed, *Earth* started out looking like a contender, for it was elegantly designed, sported a larger format than *NG*, and was printed on premium paper. But its articles, even at the beginning, seemed irrelevant; they didn't inspire me mentally or spark me to somehow get involved with *our* Earth.



S&T / CHUCK BAKER

Earth pushed up daisies in August after a run of 6½ years, which is typically the slack cut for a new publication to meet profit targets. You could see the end coming in 1996, when it devolved into a very ordinary-looking magazine. Bean-counters had clearly been at work.

All of us who love science, and want to see its message promulgated widely, should mourn this loss. We easily forget that only a decade or so ago omnibus science magazines sprang up like mushrooms after a summer rain and seemed to flourish. Then, within only a few years, they dropped dead. Upstarts like *Science '8x* were swept away along with grizzled veterans like *Science Digest*, which tried to ride a wave of hot design/hot topics and got drowned in a comber.

In my opinion, *Earth* should have carved out a niche, albeit one very different from *NG*. But for a magazine to succeed it must have relevance to readers. That's the ultimate benchmark, and that's where *Earth* dropped the ball.

What prompted this Spectrum was a chat I had with our proofreader, Sue Bryant, the afternoon before I learned *Earth* was being folded. We spent some after-hours moments shop-talking about how much we depend on each other and how important that synergy is to create the best product possible.

It's easy to invent a magazine like *Playboy;* its focus and its target market don't take much imagination! But to serve a discriminating audience — like the world community of amateur and professional astronomers — you have to empathize with its soul. That's the way it's always been around here, and that's why *Sky & Telescope* will continue to flourish.

Leif J. Robinson

P.S. And there's more bad news. In August Carl Helmers Jr. announced that the four-year-old quarterly *SETIQuest* would cease publication. At least for the immediate future its Web site, http://www.SETIQuest.com/, will continue for those interested in bioastronomy and the search for extraterrestrial intelligence.

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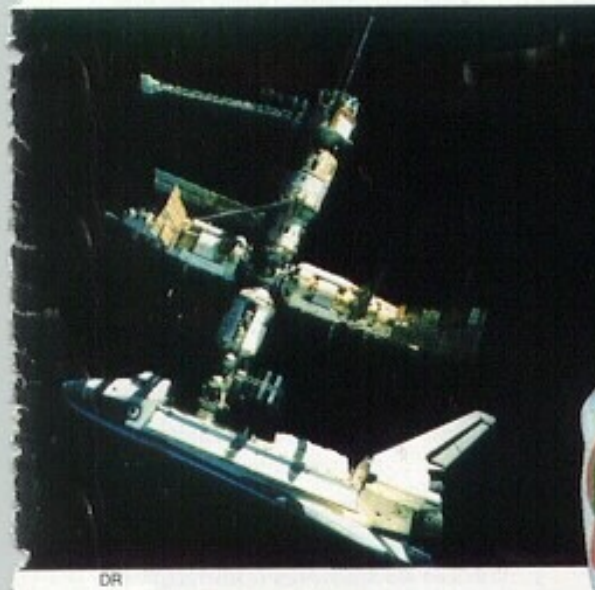

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litiques. Ils considèrent que les budgets de la recherche, dont ils déplorent quasi rituellement le trop modeste niveau, seraient bien mieux employés à l'exploration automatique de l'espace.

Pour les industriels, le séjour de l'homme en orbite impose, pour garantir sa sécurité, des critères technologiques qui sont générateurs de progrès pour l'ensemble de l'industrie. Les tenants de la présence de l'homme dans l'espace la justifient aussi par ses capacités d'adaptation, d'improvisation et d'observation, qui le rendent apte à pallier les éventuelles défaillances du système. Quant aux politiques, ils mettent en avant le prestige national et son effet sur les contribuables, bailleurs de fonds des entreprises spatiales.

Le succès de la sonde automatique américaine *Mars Pathfinder* et de son robot *So-*

AFP PHOTO NASA

Séjour GRATUIT

La NASA accueille gratuitement les astronautes européens à bord de ses navettes (le Français Jean-Loup Chrétien a ainsi participé à la rencontre d'*Atlantis* avec la station *Mir*, en septembre dernier – à gauche). Volonté de coopération ou... manœuvre de diversion?

journer (budget total, lancement compris : 1 milliard de francs) semble conforter les scientifiques. Il bat en brèche l'un des arguments des industriels et des politiques. Car les images de l'exploration du sol martien, retransmises par la télévision et sur Internet, ont ravi les spectateurs du monde entier, à commencer par les Américains. Alors que, simultanément, les problèmes de la station *Mir*, dans laquelle les cosmonautes jouaient le rôle pathétique de dépanneurs improvisés, jouaient en défaveur des vols habités.

C'est au nom de la rationalité budgétaire que Claude Allègre réclame une réorientation radicale de la politique spatiale française. Celle-ci doit être «pilotée par des objectifs économiques ou scientifiques clairs, et non par la seule technologie». Pour enfoncer davantage le clou, il ajoute : «On ne peut laisser des petits comités décider seuls [...], ce n'est pas aux industriels de décider ce qui est bon pour l'espace.»

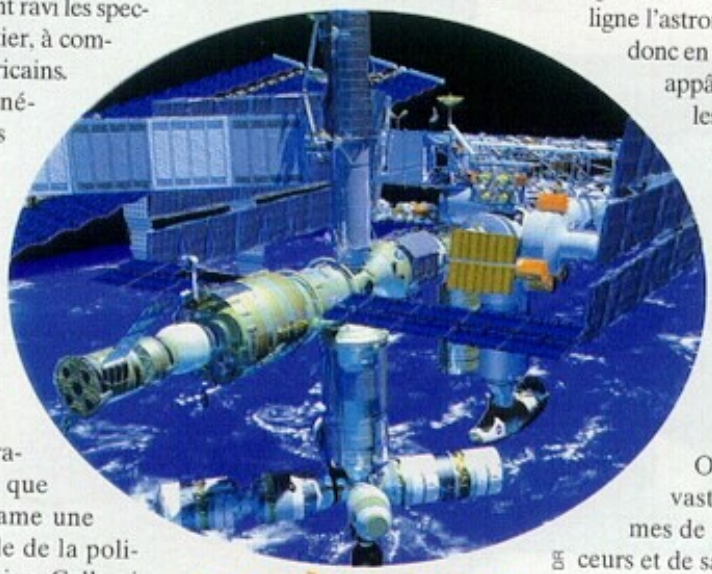
Comme dans d'autres secteurs – par exemple, la défense –, il fut un temps où, l'argent coulant abondamment, on pouvait mener de front plusieurs programmes sans trop se préoccuper de leur finalité opérationnelle. Avionneurs, motoristes, missiliers, équipementiers, chantiers navals, ateliers d'armement terrestre y trouvaient leur compte. Le prestige national primait souvent l'utilité réelle. Ces temps sont révolus.

LES PASSAGERS DE *MIR*, PATHÉTIQUES DÉPANNEURS IMPROVISÉS

Aux yeux de Claude Allègre, la présence de l'homme en orbite n'est pas une priorité. Notamment celle d'astronautes français et européens à bord d'*Alpha*. La contribution française à la station internationale (le programme entrera dans sa phase active à partir de 1999) s'élève à 400 millions de francs par an, soit 27 % de l'effort européen total pour construire *Alpha*. Dans quel but ? Pour y jouer un rôle très secondaire, estime le ministre : les Américains «nous laissent placer quelques boulons dans leur future station». Ce qu'il juge intolérable.

Il va même plus loin : il accuse les Américains de nous avoir embarqués dans ce programme uniquement pour empêcher «la France et l'Europe de développer leur propre stratégie». Surtout la France, car, dit-il, quand on parle de l'Europe spatiale, «c'est d'abord la France et, après, les autres».

Les vols effectués à bord de la navette spatiale américaine par des astronautes européens, comme Jean-Loup Chrétien il y a deux mois (vols que la NASA ne facture pas, souligne l'astronaute français), seraient donc en quelque sorte destinés à appâter les Européens, pour les impliquer dans un programme de vols habités (1). Et, si l'on en croit Claude Allègre, les neutraliser, les empêcher de mettre sur pied, ensemble, des missions vers Mars ou Vénus semblables à celles des Américains. Ou d'entreprendre de vastes et juteux programmes de mise en orbite de lanceurs et de satellites commerciaux, notamment grâce à Ariane 5.



DR

Le PIÈGE Alpha

Pour le ministre français de la Recherche, la contribution des Européens à la future station internationale *Alpha* risque de les empêcher de développer leurs propres programmes. Ce serait précisément l'objectif des Américains...

Peut-être la véhémence des arguments de Claude Allègre vise-t-elle à modifier la position de la France vis-à-vis de ses partenaires européens et des Etats-Unis. Le ministre rappelle que le CNES verse chaque année 5 milliards de francs à l'Agence spatiale européenne, soit le tiers du budget total de celle-ci, mais que, lors des décisions, notre pays ne dispose que d'une voix sur vingt. Et il en va pratiquement de même pour l'Allemagne et l'Italie, autres gros contributeurs.

Quant aux Américains, pourquoi n'accepteraient-ils pas que l'Europe participe autrement que de manière symbolique aux prestigieuses missions automatiques vers telle ou telle planète ? Une sonde martienne internationale décollant de Kourou au sommet d'une fusée Ariane 5 rassérénerait à coup sûr le bouillant ministre... ■

(1) Les séjours à bord de la station russe *Mir*, eux, sont payants. La mission de deux semaines de Claudie André-Deshays a ainsi coûté au CNES 74 millions de francs.

duce, and his clear, seductive English prose style carries one effortlessly along from discoveries to inventions and onwards to the Moon. Working on the discovery made by the Elizabethan physician, Dr William Gilbert, that a magnetic field has a finite attraction, or "Sphere of Magnetick Virtue", Wilkins argued that the Earth's own magnetic force is of limited range. This crucial mistake, however, lay in confusing magnetism with gravity, and in thinking that the diminishing power of the lodestone to affect a distant compass was the same as that which enabled a high-flying bird to glide effortlessly without moving its wings.

From the geometrically measured heights of clouds, Wilkins concluded by 1648 that the Earth's 'pull' only extended about twenty miles above its surface. If one could get a leg-up for the first twenty miles, therefore, one would have escaped the Earth's 'gravitas' or attraction, and could float towards the Moon. After discussing the aeronautical properties of demons and teams of birds, Wilkins settled upon the mechanically-propelled vehicle, or Flying Chariot: the first technologically-conceived space vehicle in history, and the ancestor of Apollo, Voyager and the shuttle.

With its hull, spring-engine and wings, the Flying Chariot was to ascend from Oxford. On reaching a height of twenty miles, its tendency to fall back to Earth would have been transcended, and one could settle down to a flight to the Moon, in much the same way as a ship could cross the ocean, once out of port. But what about food, cold and respiration?

Wilkins was now forced to use his best arguments to get around these problems, when faced with an almost complete ignorance of the nature of space. Yet food should be no problem, he suggested, for once our stomachs have been removed from the pull of the Earth, they will never feel empty, so should not need filling! Besides, there were many stories on record of people who had lived for long periods – 40 years in one case – without so much as a crumb. All that one needed was a bit of self-discipline.

Space was probably pleasantly warm, so Wilkins deduced, for unlike the Earth, it was not affected by original sin; in addition to which it formed the abode of the angels, who were always contented. And why should air be a problem? It was still disputed in 1648 as to whether the Earth's atmosphere continued up into space, and Wilkins thought that it very well might. We felt breathless on high mountains only because our corrupt lungs were used to foul air. But once we were in the mild, ambrosian airs of space our coughs and gasps would turn to exhilaration.

John Wilkins, an engraving from a portrait in Wadham College. Courtesy: Warden and Fellows of Wadham College.

And if one still felt unconvinced by this elegant rhetoric, then one could take a hamper of food, a thick overcoat, and a set of breathing sponges, such as pearl divers were said to use, to give any necessary back-up! One might also smoke a pipe.

Bizarre as some of Wilkins' ideas might sound to us today, we must bear in mind that he was the world's first scientist to think through, with the knowledge of his time, what was physically necessary to get a man into space. He wrote not as a polemicist or a fantasy writer, but as a physicist and astronomer, then filled in the gaps as well as he could.

He sincerely believed, in the 1640s, that some sort of mechanical flying machine was on the verge of perfection, and mentions several gentlemen of his acquaintance who were already making hops and experimenting with wings.

One of his most far reaching ideas, however, was the suggested use of his Flying Chariot for terrestrial flight. If one wanted to fly to America, for instance, one had only to make a twenty mile vertical ascent, switch off the motor, and hang in space. Watching the Earth turn for five hours, one waited until Boston appeared below, and then made a descent. Anywhere on the face of the Earth could be reached within 24 hours by ascending above the Earth's 'Sphere of Magnetick Virtue', waiting, then coming down. The Earth's rotation did the rest.

Although he was familiar with the telescopic appearance of the lunar surface, he withholds from speculating about the nature of the 'Selenites'. Suffice it to say, however, that he considered that 'commerce' might be established with them once the Flying Chariot had been perfected. Perhaps the cold lunar night might benefit the English woollen cloth trade! I am always amused at the prospect of the wool of the West Riding sheep being worn to keep out the midnight cold in the Mare Crisium.

No life on the Moon

Yet the abovementioned honeymoon period of scientific discovery was fast evaporating away, even during Wilkins's own life time. By the 1660s, by which time Dr Wilkins had become Bishop of Chester, the prospect of there being breathable air in space had been firmly discredited. Robert Boyle, working with the newly invented airpump from 1658, had shown that a vacuum could be produced in the laboratory. And the equally newly invented barometer registered a fall in air pressure as the airpump produced a vacuum. This fitted in very nicely with the observed fall in air pressure noted by the French physicist, Pierre Gassendi, when he took a barometer up a mountain in the Pyrenees.

The breathlessness and cold experienced on mountain tops, therefore, pointed towards a thinning of the air as one went up from the Earth's surface, so that by 1665 it seemed undeniable that space was a vacuum in which no one could breathe, even with divers' sponges, and through which no clockwork-powered Flying Chariot could ascend to the Moon.

One English astronomer whose career spanned both the honeymoon and more realistic eras of space travel ideas was Dr Robert Hooke. As a young man in his twenties, in the 1650s, Hooke had worked with Dr Wilkins in Oxford, and later mentioned their joint experiments with flying machines, conducted in Wadham College gardens. It had been Hooke, however, who built the very air pump with which he and Boyle had produced their vacuums, and some years later he became the world's first person to suffer from low pressure sickness, when he had his assistant pump the air out of a small chamber into which he had been sealed.

Although Robert Hooke never lost his interest in flying machines, right down to his death in 1703, he had long been convinced that their usefulness must be confined to terrestrial air travel. For Hooke realised by 1680 that not only was space itself airless and very cold, but that the unfluttering light of stars being occulted by

Wilkins settled upon the mechanically-propelled vehicle, or Flying Chariot: the first technologically-conceived space vehicle in history, and the ancestor of Apollo, Voyager and the shuttle.

14-day scorching days, Kepler's hero was brought back home by his spirit friends.

Kepler's book, called *Somnium*, or dream, was the first work to recognise blast-off, escape velocity, solar radiation, and the possible characteristics of people who lived on a frozen, then roasted, world, that was only a quarter the size of our own.

Kepler's *Somnium* had an enormous impact upon a whole generation of young scientifically-minded men who had no trouble in reading a book written in the international language of Latin. And nowhere was the soil more fertile for space travel than in England.

Yet the real flaw in Kepler's story was his use of demons to act as rocket motors. This defect arose not from any disbelief in demons, which were universally acknowledged to exist in the 1630s, but in their downright unreliability. After all, the devil did not keep legions of demons to provide a convenient motive power for would-be astronauts, and in that world of opposed and personified good and evil forces, a true Christian should have nothing to do with evil spirits. It was much more virtuous, and reliable, therefore, to use natural or mechanical forces to get into space.

No single illustration of Dr Wilkins' Flying Chariot exists. The above is a composite, using the wings, springs and gears mentioned in his writings. John Wilkins rises above Wadham College, on his way to the Moon, accompanied by the young Robert Hooke. From Allan Chapman's *Oxford Historical Calendar*, (1977).

Further stories

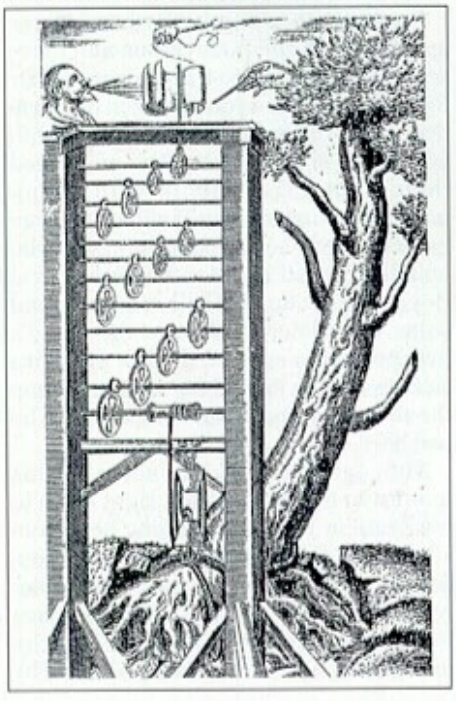
In one of his boasted adventures in exotic places, the French writer Cyrano de Bergerac, famed across Europe for his long nose, tied bottles of carefully collected dew to his jacket and faced the summer sunrise. Like the dew on the plants, the dew in Cyrano's bottles was sucked up into space, although his ascent was so rapid that he had to jettison several of them, which caused him to fall back to Earth and bruise himself.

Then Francis Godwin, a young clergyman who later became Bishop of Hereford, wrote a remarkable piece of fiction that incorporated all the best scientific knowledge of 1638. His hero was a Spanish adventurer, Domingo Gonsales, who got shipwrecked on a strange island off South America. Now, also living on the island were birds of prodigious size called Ganzas, and Domingo noticed that they migrated to and from the island, depending on the seasons.

Making an elaborate harness, with places in which to secure the Ganzas like horses onto a carriage, and with a driving seat for himself, he was able to train the birds so, using a system of flags, he could make them fly up and down, left and right. His hope was that the Ganzas would bear him across the Atlantic, and back to Spain; though he suddenly found, when aloft, that the birds were migrating – to the Moon!

What follows is one of the most beautiful passages in the whole of space travel narrative, which shows that Godwin had done his scientific homework. As the birds flew higher, he said, the beating of their wings slowed down, which indicated that as they left Earth behind, they weighed less and needed less effort to stay airborne. Similarly, Domingo Gonsales gradually saw the continents of the Earth merge so that the globe looked like a map with oceans and islands, while the sky took on a deeper blue than it did on Earth, and the stars came out.

Wilkins saw gears as capable of vastly increasing energy. A puff of breath in the upper vane produced a torque at the bottom that could uproot a tree. A similar principle, but using a powerful driving spring and wings, would get Wilkins' Flying Chariot into space. From John Wilkins' *Mathematical Magick*, (1648). Courtesy: Warden and Fellows of Wadham College.



The Warden of Wadham College

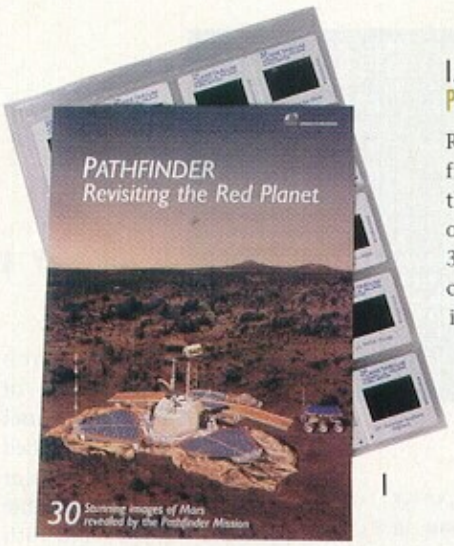
A young Oxford scholar was deeply influenced by Kepler, Cyrano, Godwin and other writers, as he had been by the telescopic discoveries of Galileo, made a decade before he was born at Fawsley, Northamptonshire. His name was Dr John Wilkins, who, in 1648, was to become Warden of Wadham College, Oxford, and the mainspring behind the founding of that experimental club which in 1660 became the Royal Society.

John Wilkins was one of science's great lateral thinkers, who had the gift to see what might happen if you took what was already known and gave it an inspired twist. A keen apostle of the Copernican theory and Galileo's telescopic discoveries, and bedazzled by the technological innovations of his time, this young Anglican clergyman wrote two books that dealt with space travel, in 1640 and 1648. What appealed to him, however, was not an imaginative story, such as those written by Kepler and Godwin, but what might be physically and factually achieved.

Gears, springs, levers and clockwork enchanted him. For why should not a clever man build a giant automator whereby a spring-driven motor actuated an enormous pair of wings to lift a 'Flying Chariot' into the air, and beyond? This was, after all, the golden honeymoon period of science and invention in European culture. Great wonders and great potentials had been revealed by 1650, yet no one grasped how limited they still were, and would remain for centuries to come.

John Wilkins was one of the first great scientific educators that Britain was to pro-

23 Images of the Cosmos



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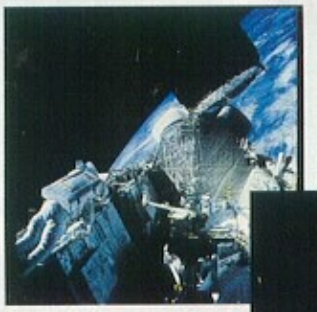

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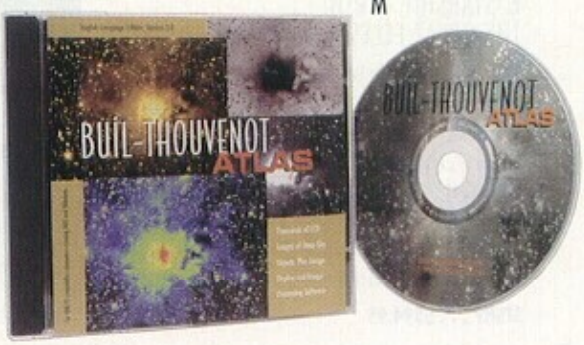

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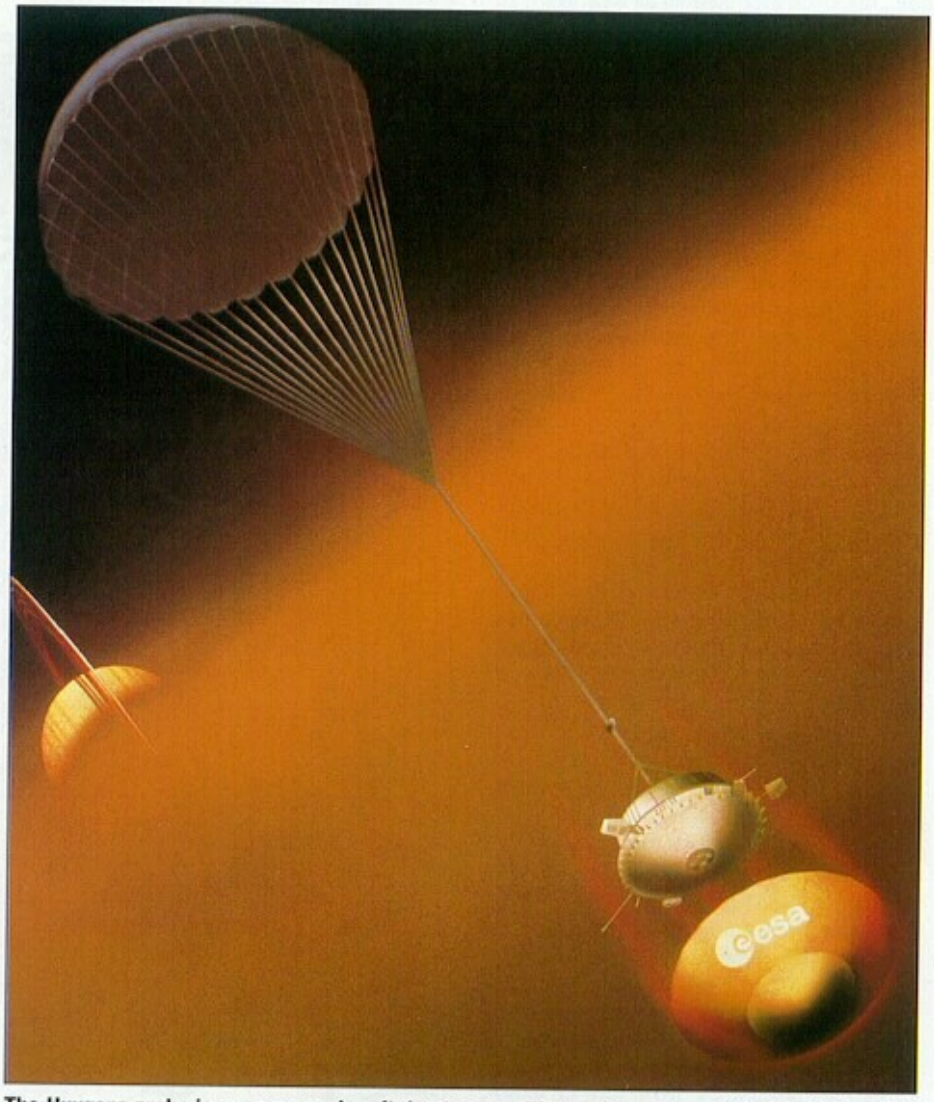
To a giant moon

Titan is the only moon in the Solar System to have an appreciable atmosphere. It is a world which may attract a future human exploration. By Stephen Baxter.

Titan is Saturn's largest moon: larger than Mercury, more massive than Pluto. It is the only moon with a significant atmosphere. If it wasn't in orbit around Saturn, we would regard it a planet in its own right. Recently the NASA/ESA Cassini-Huygens probe has been sent on its way: a Saturn orbiter with a Titan lander, due to arrive in 2004.

Titan is a fascinating world scientifically. But why would humans ever go there? And if they did, what kind of world would they find?



The Huygens probe is an unmanned craft due to enter Titan's atmosphere in 2004. Photo: ESA

The hidden ground

Titan is an ice moon, a body like Pluto, Triton, and Ganymede. At the core is a ball of rock overlaid by a shell of ice, nine hundred kilometres thick. And on the surface, over a water ice crust, lies a slush of complex organic compounds. Titan takes sixteen days to orbit its primary, keeping the same face to Saturn.

What distinguishes Titan is a thick atmosphere, mostly nitrogen (like Earth's), with some methane, argon and hydrogen. The atmosphere is double the mass of Earth's, exerting 50 percent more pressure and it is laden with haze-like a thick city smog, formed by particles the size of those in cigarette smoke. The smog hides the surface from us; from space, Titan is a featureless orange-brown ball.

A landing on Titan would be comparatively easy, thanks to the frictional resistance of the thick atmosphere. Huygens is a direct-entry probe. A manned craft would probably enter from low circular orbit around Titan, shedding most of its orbital velocity of 1.87 km/sec against atmospheric friction. This compares to the Earth-orbital velocity of 7.9 km/sec survived by the Shuttle, and the 10.8 km/sec survived by Apollo capsules returning from the Moon.

The peak deceleration would be around 1.5G – eminently survivable by an Apollo-type landing capsule. In the later phases a slow descent, perhaps in a glider craft or under a steerable parachute, would make possible a search for a surface shelter.

Stepping out of their landers onto the slushy ground, the explorers will find unpromising weather: cold, overcast and smoggy. There are low clouds of liquid methane, higher cirrus clouds of ice. Perhaps there is lightning. The temperature is a mere 94K, nearly two hundred degrees below the freezing point of water. But the deep cold is the reason such a small world has been able to cling onto its air.

And it is dark. Hidden beyond the kilometres of smog, the distant Sun has only one percent of its brightness at Earth's distance. The explorers should pack flashlights. And, just as the smog hides the surface from us, so the sky is hidden from the ground: sadly, the rings of Saturn are forever invisible from Titan's surface.

The air of a moon

We do not know, yet, how the atmosphere got there. Perhaps Titan's nitrogen is primordial, perhaps it dates from the formation of the Solar System itself, as comet-like icy planetesimals rained down over Titan's new surface. Or perhaps ammonia and methane were incorporated into ices in the core of young Titan, and then leaked out to form a thick primeval atmosphere over an ammonia ocean. Over the next hundred million years, the ammonia was broken up by the action of sunlight, releasing nitrogen. The atmosphere cooled and the old ocean froze over.

However it was formed, the atmosphere has been shaped by billions of years of chemistry. Unlike Earth, Titan has virtually no magnetic field of its own so the Sun's ultraviolet radiation, the solar wind and magnetospheric plasma from Saturn all attack the upper atmosphere, driving a lot of organic chemistry.

The ultraviolet destroys upper atmosphere methane, which then combines with nitrogen to form complex molecules. There are hydrocarbons, molecules made of carbon and hydrogen atoms, such as natural gas, petroleum and

24 Maps and Globes

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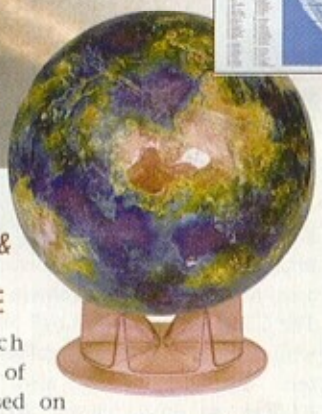

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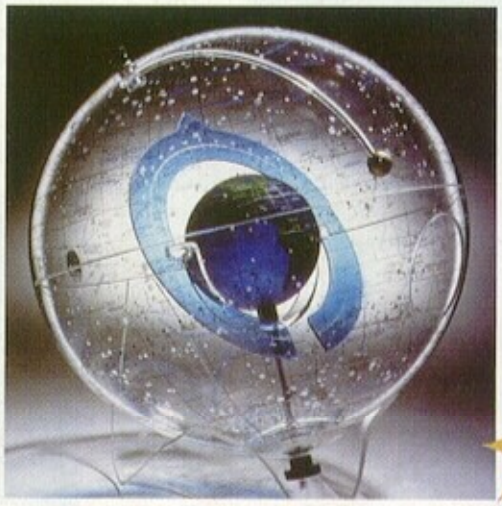

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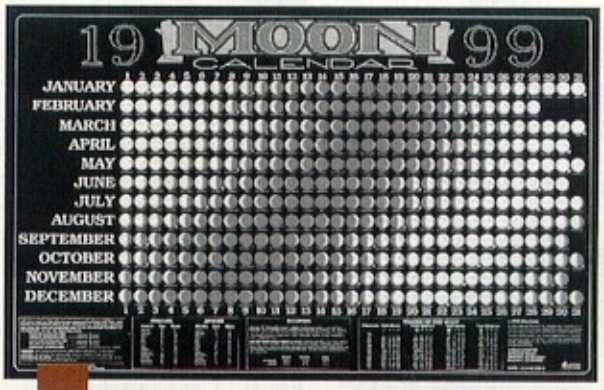

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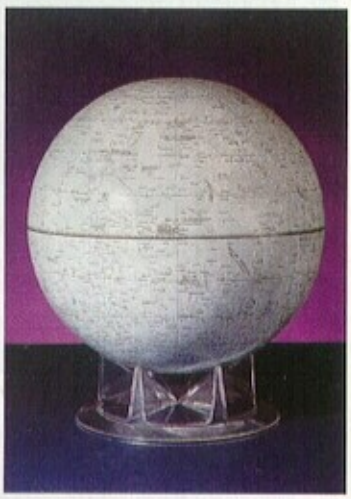

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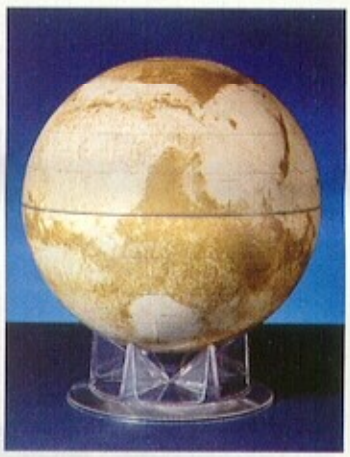

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AP

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BILDERBERG

ARBEIT Die Rationalisierung wird weitergehen – und der Arbeitsplatzabbau auch. Eine Arbeitslosenquote von 36 Prozent scheint denkbar. Damit es nicht zum Schlimmsten kommt, müssen wir umdenken: Wie kann die Arbeit im dritten Jahrtausend aussehen? 64

VAN RAVENSWAAY

MARS-MENSCHEN Die Besiedelung des Mars rückt in greifbare Nähe: Wenn alles klappt, werden Im Jahr 2007 die ersten Menschen auf dem roten Planeten landen. P. M. schildert, wie der Mars zur zweiten Erde werden soll 8

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SIMULATOREN Hier hat die virtuelle Welt einen ganz praktischen Nutzen: In High-Tech-Simulatoren lernen Piloten, LKW-Fahrer, Zugführer und Soldaten ihr Handwerk. Immer leistungsfähiger werden die Anlagen: Bald kann man sogar Kriege im Simulator führen 28

TITEL: AUS: A. PLOUM "SPIEGEL DES UNIVERSUMS" HOPPERS VLG., AP, L. GUBB/IMAGE WORKS/FOCUS, P. MENZEL/FOCUS

Snapshots from Mars

THE FIRST SPACECRAFT to land on Mars in more than two decades, the Mars Pathfinder has given the world a close-up look at the rock "Barnacle Bill" and other features on the surface of the Red Planet during a spectacular mission. Arriving on July 4, Pathfinder demonstrated that airbags perform just as well in spacecraft landings as they do in car crashes. Photos taken by the lander, together with soil and rock analyses done by the microrover Sojourner, are providing important clues about the geologic history of Mars. *marsweb.jpl.nasa.gov*

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Popular Science DECEMBER 1997

Science et vie 12.97

ACTUALITÉ

AIMANTS GÉANTS SUR MARS

● Première découverte du satellite *Mars Global Surveyor* : la planète rouge présenterait des anomalies magnétiques. Au cours de ses orbites, la sonde a en effet détecté des zones bien délimitées (d'un diamètre pouvant atteindre 160 km), situées sous la surface, qui réagissent comme de gigantesques aimants. Ces restes

DR

dispersés d'un ancien champ magnétique, qui étonnent les astronomes, perturberaient tout explorateur qui voudrait se guider sur Mars à l'aide d'une boussole. J.-F. R.

Peter Bond

Organic molecules on Callisto and Ganymede

As the Galileo spacecraft bounces around the Jovian system, its instruments are returning a mass of new information about the planet and its four Galilean moons. In a recent paper in *Science,* American scientists report the discovery of organic substances on the surfaces of the two largest moons, Ganymede and Callisto.

As one would expect for such icy worlds, water ice dominates the spectral information obtained by the near-infrared mapping spectrometer (NIMS). However, other weak spectral signatures have been detected, particularly on Callisto. The complex way in which these spectral absorptions vary in strength with location indicates the presence in small amounts of a number of different materials on the surfaces of these satellites.

The data suggest that the main candidates are carbon dioxide, sulphur dioxide and substances known as tholins which are composed of carbon and nitrogen. The authors suggest that some or all of these molecules could have been created by the action of solar ultraviolet radiation and particle radiation from the Jovian magnetosphere. Similarities with spectra of interstellar ices and some meteorites indicate that the organic substances on the surfaces of the satellites may have been supplied by incoming debris.

Peter Bond

12.97 Astronomy Now

distortion seen on Triton

EVENT HORIZON

Shortcut to Mars

A round-trip journey to Mars that now takes three years could someday take as little as 45 days, says physicist Carlo Rubbia, winner of the 1994 Nobel Prize for physics. Rubbia has proposed a nuclear-powered ship that would rely on a synthetic isotope known as americium-242. Splitting apart americium atoms with neutrons generates ionized fragments that create intense energy when passing through hydrogen. In fact, one gram of americium can supply the same energy as one ton of conventional chemical propellant. Rubbia is currently working with Italian and European space agencies to make the spacecraft a reality.

AXAF Delayed Again

P.M. EDITORIAL

Chefredakteur
Hans-Hermann Sprado

Liebe Leserin, lieber Leser,

man kann die erhitzten, miesepetrigen Gesichter verstehen, die nach einer Sitzung des Bündnisses für Arbeit vor den Mikrofonen und Kameras auftauchen, wenn man weiß, was die Politiker, Arbeitgeber und Gewerkschafter vermutlich längst schon wissen: Wenn die Wirtschaft alle heute verfügbaren Technologien zur Rationaliserung einsetzen würde, hätten wir in Deutschland 36 Prozent Arbeitslose – das wären rund 3,5mal soviel, wie die offizielle Statistik (10,2 Prozent im November 1998) der Bundesanstalt für Arbeit in Nürnberg ausweist.

Wie realistisch sind angesichts dieser niederdrückenden Einschätzung die Pläne der Regierung Schröder, die vollmundig angekündigt hat, innerhalb dieser Legislaturperiode die Arbeitslosenzahl von vier auf drei Millionen zu senken? So wünschenswert und dringend notwendig dieser Erfolg ist – tatsächlich nimmt auf der Welt, zumindest in allen Industrienationen, die Automatisierung zu und die Arbeit ab. Wird der Mensch also überflüssig? Unrentabel wie das Pferd mit Beginn des Industriezeitalters im vorigen Jahrhundert? So weit wird es nicht kommen, verspricht P.M.-Redakteur Joseph Scheppach, der in seinem Bericht der Frage nachgegangen ist: »Was tun wir, wenn uns die Arbeit ausgeht?« (Seite 66). Trotz einer Milliarde Arbeitslosen weltweit, so hat er herausgefunden, gibt es durchaus Erkenntnisschübe, die berechtigten Anlaß zu der Hoffnung geben, daß wir im nächsten Jahrtausend nicht nur mehr – weil andere – Arbeit haben werden, sondern überdies auch noch mehr Spaß und Zufriedenheit dabei.

Darf ich Sie auch auf unsere neue P.M.-Perspektive-Ausgabe »**Wunder, Rätsel, Phänomene**« hinweisen, die in diesen Tagen erscheint? Sie beschreibt, so finde ich, treffend die Suche der Wissenschaft nach dem Unerklärlichen zwischen Himmel und Erde, und davon gibt es bekanntlich noch eine ganze Menge.

Herzlichst Ihr

Hans-Hermann Sprado

P.M.

Peter Moosleitners interessantes Magazin

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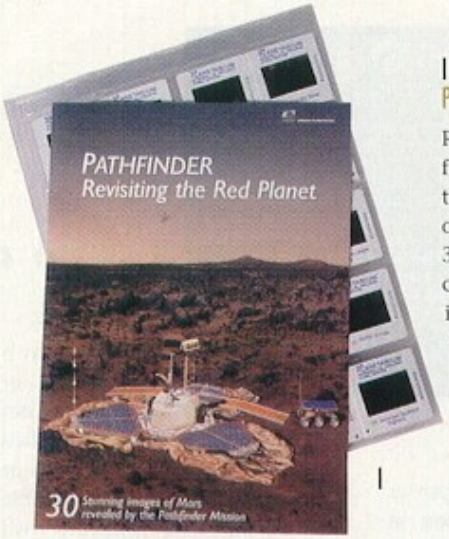

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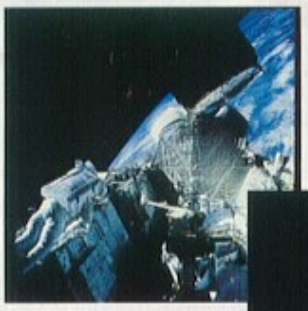

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Requirements: PC: 486/Pentium with VGA color monitor, super VGA (16 million colors) recommended; 8 MB RAM, 16 MB recommended; Microsoft MS-DOS and Windows 3.1x or higher, Windows 95/98/NT recommended.

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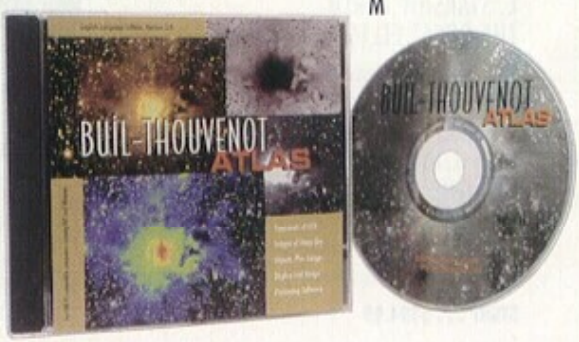

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the dark side of the Moon, as seen through a powerful telescope, showed that the Moon was airless as well. The prospect of life on the Moon, therefore, had become untenable by 1680.

Life elsewhere

But the prospect of life on other worlds was a different story altogether, for not only were the planets seen as potentially habitable, but even star-planets as well. Indeed, educated opinion in the 17th century saw a necessity for the existence of extraterrestrial intelligent life, for why had God made habitations without inhabitants? Surely, a God who filled the Universe with vast and swirling worlds, no longer mere points of light, could not have restricted His life-giving beneficence to a single one of them.

This was the argument suggested by the French astronomer Bernard de Fontanelle in his study of the *Plurality of Worlds* in 1686, and by the Dutch brothers Christiaan and Constantijn Huygens at around the same time. It had been the Huygens brothers who had pioneered the use of large-aperture (6-inches) long focal length telescopes in the 1650s, and when Christiaan wrote to Constantijn in 1695, he speculated upon the characteristics of extraterrestrial beings.

Surely, he argued, as one God made everything, these space beings must possess an intelligence like that of our own. And as intelligence includes curiosity about the world in which we live, combined with technological ingenuity, it is not beyond the bounds of plausibility to consider the prospect of them looking at us through powerful telescopes!

The debate about the existence and characteristics of extra terrestrial life carried on into the 19th century, when scientists like William Whewell, Master of Trinity College, Cambridge, discussed the possibility in the 1840s. And in addition to its discussion amongst astronomers, we must not forget that the subject of life on other worlds never lost its popular appeal among lay audiences. Although no scientists took it seriously, the American journalist Richard Adams Locke's invention about Sir John Herschel discovering intelligent, copper-coloured creatures on the Moon in 1835 sent the circulation figures for the failing New York *Sun* newspaper soaring through the roof.

It is also important to bear in mind that the discussion of life in space produced no religious reaction. Not only did two of the pioneering authors in the field, Godwin and Wilkins, become Bishops in the Church of England, but the very concept of an inhabited universe was seen as spiritually exciting in so far as it gave a new perspective to God's glory. The biggest theological problem lay in whether the extraterrestrials were damned or saved. For if they were damned, did it mean that Jesus Christ had to suffer on every planet in the Universe as a way of redeeming them?

Cyrano de Bergerac's dew-filled bottles are lifted up into space. From Bergerac's *Comical History*, English edition, (1659). Courtesy: Warden and Fellows of Wadham College.

But after the realisation that space was a vacuum and that spring-driven Flying Chariots would never get off the ground, all hope was abandoned of travelling to other worlds. And similarly, the Huygens brothers realised that even if the inhabitants of Saturn were indeed watching us through telescopes, it was unlikely that they would ever touch down in Amsterdam. Not until writers like Jules Verne and H. G. Wells in the 19th century did space travel re-emerge as a serious speculative genre in literature, and not until the last fifty years did people think of it as a physical reality.

Yet it is remarkable how so many of the questions which we ask today, about life on other worlds and space travel, had already been asked and discussed to a very high level of sophistication over 300 years ago. For when, during the winter of 1610, Galileo's new telescopic vision of the Sun, Moon, and Planets was creating a new understanding of the Solar System, it was also heralding in the first space age.

Dr Allan Chapman is a professional historian at Oxford University and a contributing consultant to *Astronomy Now*.

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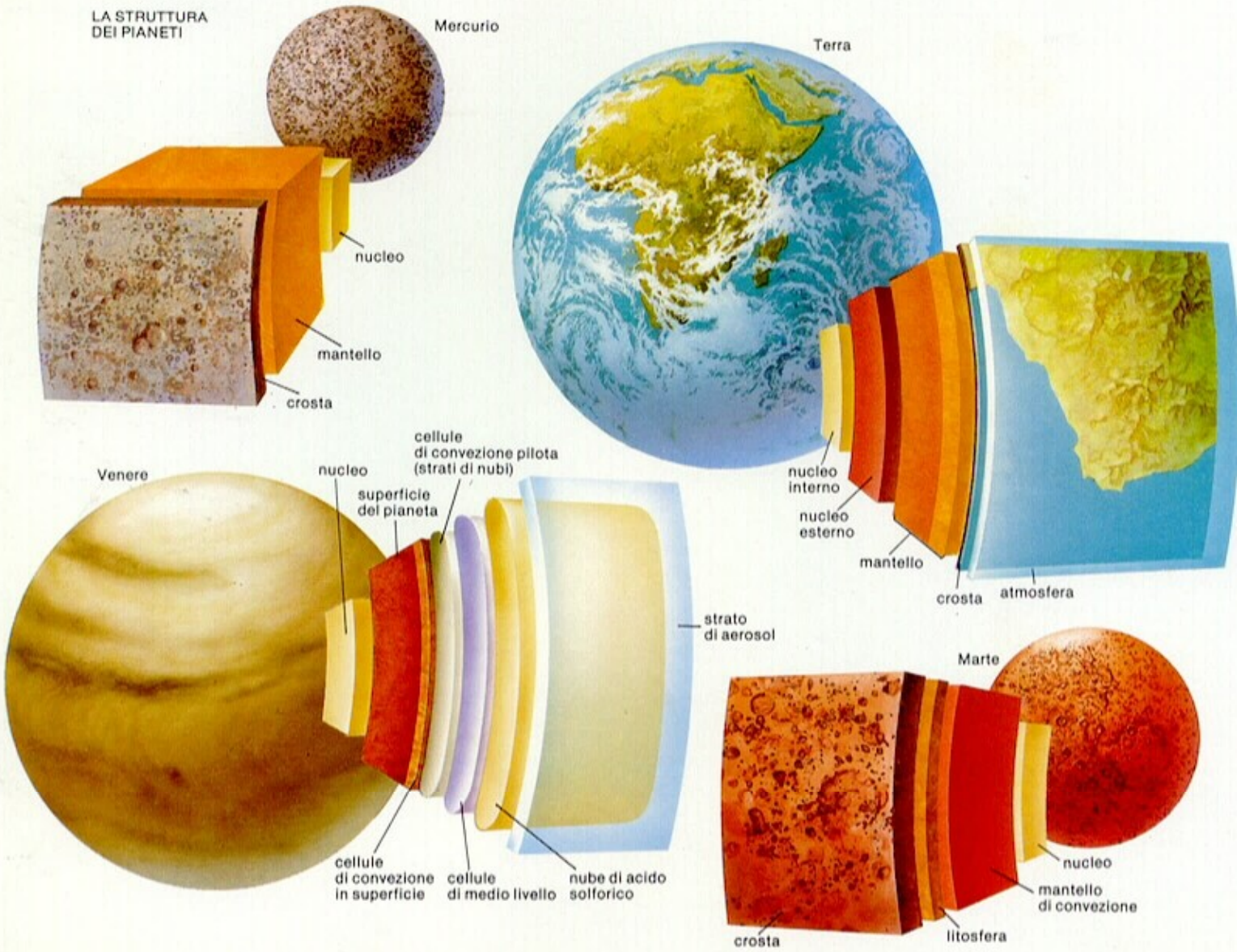
dalle regioni polari a quelle desertiche fu tutt'uno. La fine dell'800 fu caratterizzata da accesi dibattiti fra i piú famosi studiosi di questo pianeta, come l'italiano Giovanni Schiapparelli, il greco Eugenio Antoniadi e l'americano Percival Lowell. Perché fosse definitivamente accantonata l'ipotesi della vita su Marte si è dovuta aspettare l'era delle sonde spaziali. Dalla metà degli anni '60 in avanti una serie di *Mariner* ha fotografato Marte a piú riprese, trasmettendoci le immagini di un pianeta cosparso di crateri simili a quelli lunari, ma anche di immensi vulcani. Uno di questi, il Monte Olimpo, ha un diametro di 500 km e, finora, il primato di vulcano piú grande del sistema solare.

Marte presenta anche delle strutture simili a letti di fiume prosciugati, segno che probabilmente in un'epoca passata ci doveva essere acqua e che il clima dovette poi evolvere in senso desertico. Infatti Marte è caratterizzato da grandi tempeste di sabbia che possono durare per parecchi mesi. Su Marte è stata fatta atterrare nel 1976 la sonda americana *Vicking* per la ricerca di vita a livello elementare, ma i risultati sono stati negativi. Quanto ai canali osservati nell'800, tutti ormai sono convinti che si trattasse di illusioni ottiche generate da particolari condizioni di luce.



ASTRONOMIA

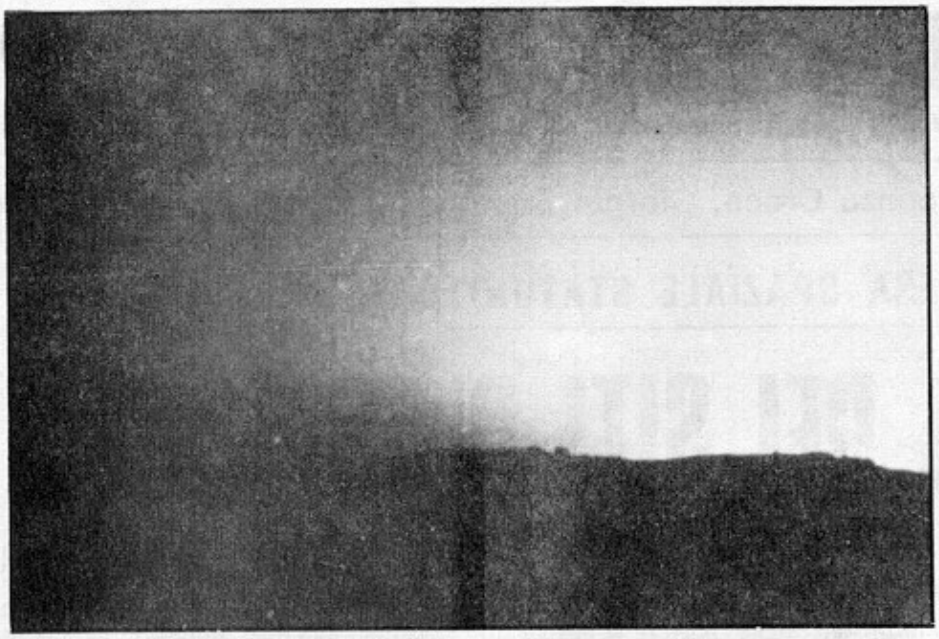
Rubrica a cura di Vincenzo Croce, Giorgio Buonvino e Carlo Andreini

RELAZIONE SULL'IMPRESA SPAZIALE STATUNITENSE (3.a PUNTATA)

LA SCELTA DEI SITI D'APPRODO

L'orbita in cui il VIKING 1 si è inserito il 19 giugno, entrando nel campo gravitazionale di Marte, è inclinata di 38° sull'equatore del pianeta ed è fortemente eccentrica, poiché raggiunge i 32.500 km. all'*apoastro* e 1500 km al *periastro*. In corrispondenza di questo secondo punto orbitale, l'ORBITER transita direttamente sopra il luogo d'attracco del rispettivo LANDER. Nel caso del VIKING 2 le condizioni dinamiche non variano sostanzialmente, salvo che l'orbita risulta molto più inclinata (56°). La scelta del luogo d'atterraggio (o di « ammartaggio »!) ha implicato l'esame di una notevole varietà di parametri dalla cui esatta valutazione dipendeva strettamente il successo di tutta l'impresa. Durante la primavera passata, accurati sondaggi radar vennero effettuati al gigantesco paraboloide del radiosservatorio di Arecibo ed al Jet Propulsion Laboratory di Pasadena, e il risultato fu che almeno il 20% della superficie marziana doveva essere costituito di strutture ruvide e porose. Per la sicurezza dell'approdo la natura del suolo non doveva possedere troppe accidentalità; né offrire una struttura presumibilmente cedevole al peso del LANDER; né doveva far parte di una regione troppo elevata affinché la minor pressione atmosferica e la soggezione a maggiori escursioni termiche, implicando una più bassa probabilità di presenza del vapor d'acqua, non vanificassero gli scopi principali delle esperienze programmate. Inoltre la zona non doveva essere battuta dai venti impetuosi che si sapevano soffiare in molte regioni marziane, poiché la loro violenza avrebbe potuto travolgere e rovesciare il laboratorio automatico (su Marte esso avrebbe pesato tre volte di meno che sulla Terra: ossia circa 200 kg) e in ogni caso si sarebbe rischiato l'inceppamento di qualche dispositivo meccanico a causa dell'infiltrazione delle polveri sollevate in grandi quantità. Le caratteristiche topografiche desiderate dovevano poi estendersi su di un'area non inferiore ai 100 x 270 km perché questo era il margine di sicurezza da concedere al LANDER perché le probabilità di successo raggiungessero il 99,7%. Alla base NASA di Pasadena una candidatura di tre siti d'approdo per il VIKING 1 era già stata proposta preventivamente da Harold Masursky e dal suo staff sulla base dei rilievi fotografici del suolo di Marte eseguiti da MARINER 9. Essi erano tutti compresi in una regione nominata *Depressione di Chryse*. Alternativamente, una seconda località in *Lago del Tritone* a 90° di longitudine est e a 20° di latitudine nord, pressappoco agli antipodi della precedente, era stata presa in considerazione, ma il 4 luglio questa veniva esclusa quando le immagini trasmesse dal vettore l'avevano rivelata troppo accidentata e butterata da piccoli crateri. Poiché la scelta di altre località avrebbe imposto modifiche continue alla traiettoria dell'ORBITER con conseguente consumo di propellente, e dato che l'orbita d'inserimento del VIKING 1 possedeva il suo punto più ravvicinato in corrispondenza della *Depressione di Chryse*, veniva deciso di scegliere in quest'ultima località il luogo definitivo di approdo. Esaminando le immagini delle telecamere riproducenti strutture larghe meno di 100 metri, a Pasadena gli specialisti, il 19 luglio, trovavano dapprima un'area promettente, ma lo scandaglio radar dimostrava ben presto che la superficie era ancora troppo rugosa e craterizzata. Durante le orbite successive si delineava, infine, una depressione abbastanza vasta nella quale il vento sembrava aver stratificato sabbie ed addolcito le asperità. Il luogo era centrato alle coordinate di 47° ovest e 22° nord e distava 180 miglia

*La brulla e sassosa distesa d'*Utopia, *obbiettivo della missione VIKING 2, fotografata subito dopo il contatto.*



Sul deserto orizzonte marziano scende la sera. Il tramonto del Sole fotografato dal LANDER 2.

dal precedente: appariva come l'area più promettente e pertanto veniva deciso di considerarla località definitiva per la discesa. Finalmente, dopo 29 orbite esplorative il giorno 20, un comando da Terra inviava il consenso al calcolatore di bordo affinché iniziasse a fornire le istruzioni per l'approdo. La « finestra » temporale, entro la quale lo sganciamento del LANDER doveva assolutamente avvenire, aveva una durata di 3 ore. Da questo istante lo svolgersi delle operazioni non era più coordinabile da Terra perché il ritardo di circa 40 minuti fra la partenza ed il ritorno dei radiosegnali alla distanza di Marte, diveniva incompatibile alla tempestività con cui dovevano esser prese le decisioni e controllato il funzionamento dei diversi dispositivi: al computer del VIKING veniva perciò affidata la sorte dell'impresa. Quarantacinque minuti dopo l'avvio dell' operazione, le molle di ritegno del LANDER all'ORBITER scattavano separando i due moduli. La capsula contenente il LANDER si distaccava alle 10,51 (ora italiana) e accendeva i suoi razzi per 24 minuti al fine di rallentare la sua velocità iniziale di 4824 km orari. Scendendo lungo una traiettoria parabolica, la capsula prendeva gradualmente l'assetto orientandosi con lo scudo termico (il cosiddetto *aeroshell*) verso gli strati atmosferici marziani. Alle 13,48 allorché si librava a 200 km di quota, essa prendeva contatto con l'atmosfera esterna nella quale iniziava a precipitare liberamente; a 6000 metri d'altezza s'apriva il paracadute di frenamento, largo 17 metri; a 3000 l'*aeroshell* veniva espulso liberando la struttura del LANDER; a 1500 il modulo accendeva i suoi propulsori di sostentamento che rallentavano gradualmente la velocità di discesa portandola da 5 km al minuto a solo 2 metri al secondo.

In queste condizioni, dopo appena 10 minuti dall'ingresso nell'atmosfera di Marte, alle 13,58 (ora italiana: 16,30 ora locale marziana) il LANDER toccava finalmente il suolo del pianeta ad appena 30 km dal punto previsto! Un segnale di conferma dell' avvenuto contatto partiva allora dall' ORBITER irradiandosi verso la Terra, ove giungeva 18 minuti ed 8 sec. più tardi. Nel frattempo le telecamere del modulo iniziavano ad entrare in funzione inviando le prime immagini della scena circostante. Per quel che riguarda il VIKING 2, penetrato in orbita circummarziana 18 giorni dopo, cioè il 7 agosto, le operazioni si sono svolte in modo del tutto analogo in previsione della discesa stabilita per il 3 settembre successivo nella regione di *Cydonia*, ai limiti della cappa polare boreale. Dopo un certo numero di orbite esplorative, gli scienziati di Pasadena, incoraggiati da alcune segnalazioni dei detector sensibili alla presenza di tracce minime di vapor d'acqua, mutavano avviso ed opinavano per la regione di *Utopia*, un'area vasta e pianeggiante situata a circa 6-7000 km a nord-est del punto d'approdo del primo LANDER. Le coordinate del luogo erano 226° ovest e 48° nord, pressappoco la medesima latitudine di *Cydonia*, e verso di esso il LANDER 2 iniziava la sua traiettoria d'accostamento dopo l'avvenuta separazione dal modulo orbitante.

Un incidente imprevisto metteva improvvisamente in agitazione il centro di controllo di Pasadena: ci si era resi conto, ad un tratto, che una caduta d'energia nell'alimentazione del trasmettitore ad alta potenza, si stava verificando a bordo dell'ORBITER 2. La faccenda provocava la perdita di contatto fra la Terra e i due moduli VIKING perché la trasmissione dei dati informativi sulle operazioni, smistati automaticamente sulla seconda antenna a basso guadagno, era da ritenersi pressoché perduta, attesa la notevole distanza di Marte. Comunque alle ore 0,58 minuti e 20 secondi (ora italiana) del 4 settembre, un debolissimo segnale proveniente dall'ORBITER veniva a confermare la perfetta conclusione della seconda missione VIKING, anche se l'atterraggio risultava avvenuto su di un pendìo inclinato di 8° sull'orizzonte.

Ambiente marziano e primi risultati scientifici

La *Depressione di Chryse* ove è disceso il primo LANDER è una regione pianeggiante d'intensa colorazione rossastra per la presenza di particelle d'ossido ferroso, la quale è situata a 5-6 km al disotto del livello medio della superficie del pianeta. Dalle prime immagini trasmesse è apparsa costellata di rocce più o meno aguzze, affioranti da un fondale costituito di sabbia finissima ammucchiata in leggere ondulazioni laddove il terreno è più libero ed i venti hanno più presa. Come abbiamo riferito, i dettagli più minuti visibili all'orizzonte, distante qualche chilometro, possiedono le dimensioni di palle da golf. Ad appena una decina di metri dal modulo è visibile un grosso masso ovale, lungo circa 1 metro e 1/2, di colore molto oscuro e mostrante evidenti segni di erosione eolica. La tinta del cielo verso l'orizzonte, dopo l'opportuno aggiustamento dei registri cromatici delle telecamere di bordo, è apparsa d'un rosa carico, alquanto caliginosa per la presenza, in sospensione, di particelle finissime di polveri sollevate da una precedente tempesta di sabbia.

Luogo: Italia

Tema: presentato progetto per un motore nucleare sulla rotta Terra-Marte.

E' stato presentato durante un incontro a Palazzo Chigi tra il presidente del Consiglio D'Alema e l'astronauta John Glenn un progetto del fisico Carlo Rubbia per un motore di tipo nucleare, che ridurrebbe il tempo di un viaggio Terra-Marte-Terra da quattro anni ad un solo anno. L'Italia si occuperà dello studio di prefattibilità.

Nuova Stampa
5-6-97

Fate il vostro gioco

MARTE (PAGINA 2)

PASCAL LEE, NASA HAUGHTON-MARS PROJECT 2001

DA VEDERE

Marte sulla Terra

Forse non visiterete mai il pianeta rosso, ma sulla Terra esistono degli ottimi surrogati: si tratta di luoghi che presentano caratteristiche piuttosto simili, sia di tipo climatico (freddo e asciutto) che geologico (vulcani e crateri da impatto).

■ **L'Isola di Devon**, nell'Artico canadese (sopra) ospita un vasto cratere da impatto, e fortuna vuole che si trovi in un deserto polare. Qui, ogni estate, arrivano esperti di Marte per studiare l'ambiente e simulare l'esplorazione del suolo marziano.

■ **Le Valli Aride dell'Antartide** coprono un'area priva di ghiaccio di 4000 chilometri quadrati. Sono talmente fredde e aride che alcune specie di licheni e di batteri sono costretti a vivere all'interno delle rocce: un tipo di nicchia ecologica che potrebbe ospitare forme di vita anche su Marte.

■ **Il Mauna Loa** delle Hawaii, il più grande vulcano sulla Terra, sembra un modello in scala ridotta dell'Olympus Mons marziano, il più grande del Sistema Solare. Entrambi sono vulcani a scudo: coni larghi con dolci pendii formati da lava fluida.

■ **L'Islanda** è un laboratorio naturale dove studiare l'interazione fra ghiacci e vulcani, le stesse forze che hanno modellato la superficie marziana.

DA PROVARE

Ore marziane

I rover che esplorano Marte di giorno sono guidati dalle informazioni radiotrasmesse di notte dal Jet Propulsion Laboratory di Pasadena, in California. Poiché in media l'intervallo tra un'alba e un'altra su Marte è di 24 ore, 39 minuti e 35 secondi, gli operatori del Jpl, sincronizzandosi sui tempi dei rover, iniziano a lavorare 40 minuti più tardi ogni giorno terrestre. Così, dopo due settimane dall'atterraggio dei rover, previsto il 4 gennaio, avvertiranno un jet-lag pari a uno spostamento di nove ore sulla Terra. Per conoscere l'ora esatta su Marte andate a: *www.giss.nasa.gov/tools/mars24*

L'alba su Marte "vista" dal Mars Pathfinder della Nasa, 1997.

NASA/JPL

CONSIGLI

Pagine rosse

Nella letteratura fantastica, Marte occupa sicuramente un posto d'onore: come nuova frontiera da conquistare, o come base di partenza di alieni benevoli o ostili (e magari verdi e con le antenne). Ecco una breve lista di classici della fantascienza ambientati sul pianeta rosso:

■ ***La principessa di Marte*** di Edgar Rice Burroughs (1917). Città incantate, mostri brutali e fanciulle da liberare popolano il pianeta immaginato dall'autore di *Tarzan*.

■ ***Cronache marziane*** di Ray Bradbury (1950). L'epopea della colonizzazione di Marte in una delle prime opere che hanno elevato la fantascienza a genere letterario di serie A.

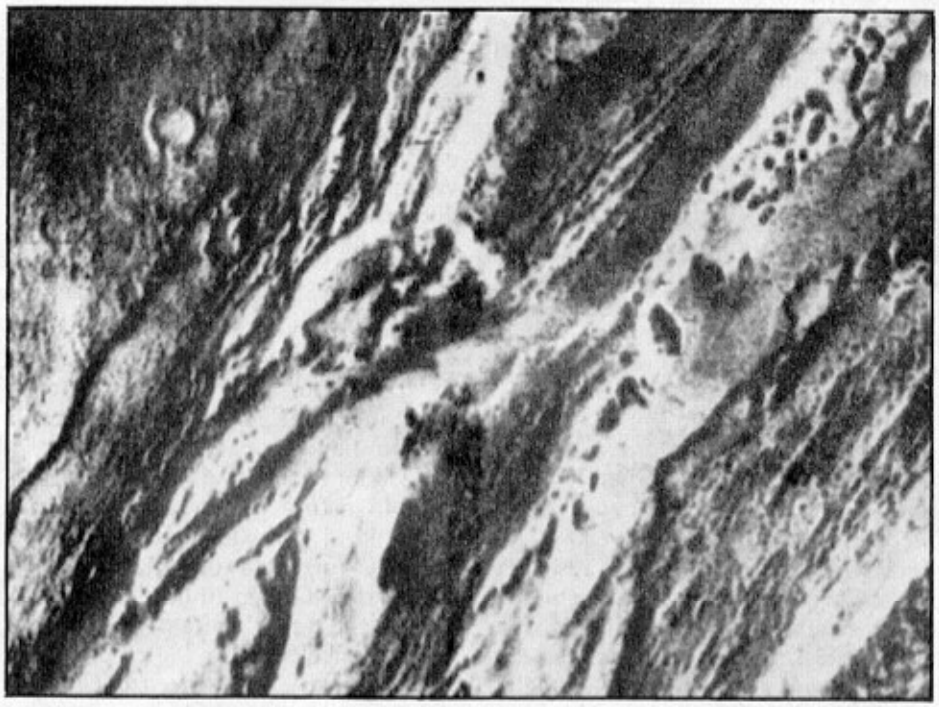
■ ***Memoria totale,*** di Philip K. Dick (1966). Il Marte reale e quello virtuale sono gli scenari di questo racconto firmato da uno degli scrittori più visionari del secolo, da cui è stato tratto il film *Atto di forza* con Arnold Schwarzenegger.

ESCLUSIVA WEB

Prodotti multimediali su Marte, fotografie, e gli appunti dell'autore Oliver Morton, a: nationalgeographic.com/magazine/0401

La regione desertica di *Chryse* è posta alla confluenza di un certo numero di tracce canaliformi scavate un tempo dall'acqua che dovette scorrervi copiosa. Il prezioso elemento è ora assente, in forma liquida, sulla superficie del pianeta perché, a causa della ridotta pressione aerea (5-6 millibar, ossia 6 millesimi di quella terrestre) esso tende a sublimare direttamente in minuti cristalli sospesi nell'atmosfera. Come il VIKING 2 sembra aver dimostrato, forse una certa quantità di acqua è concentrata in un miscuglio di brina e di polveri (il cosiddetto *permafrost*) gelato dai violentissimi fenomeni d'irradiazione notturna non temperata dalla protezione di un adeguato involucro atmosferico: inoltre essa potrebbe ritrovarsi insieme all' anidride carbonica solidificata che ricopre le regioni polari come, del resto, alcuni rilevamenti effettuati dagli ORBITER indurrebbero fortemente a credere. Pertanto, se forme biologiche ancora sussistono su Marte, gli specialisti hanno ritenuto che le maggiori probabilità di rintracciarle risiedono proprio in località depresse come *Chryse* ove la pressione è un po' più alta (8 millibar), ovvero abbastanza prossime alle calotte polari, come *Utopia*, per entrambe le quali i monitor all'infrarosso avevano indicato concentrazioni di vapor d'acqua e « centri caldi ». I dati della stazione meteorologica di bordo hanno rivelato velocità del vento pari a molte decine di km orari; variazioni di temperatura dai 0° — 10° sotto zero al mezzogiorno, fino a valori di —70°, —80° durante le ore notturne o poco prima dell'alba. Lo spettrometro di massa ha riconosciuto la presenza di almeno nove tipi diversi di gas nella composizione dell'atmosfera, fra i quali è preponderante il *biossido* e l'*ossido di carbonio* (CO_2 e CO). L'*azoto* si presenta sotto forma di due isotopi insieme all'*argon* ed al *kripton*, gas inerti e pesanti: lasciano arguire l'antica esistenza di una densa atmosfera primitiva, nonché una naturale fenomenologia di radioattività da parte delle rocce. La scarsa gravità marziana ha fatto sì che quasi tutti i componenti gassosi si siano dispersi nello spazio a cominciare dalle sostanze più volatili: i residui si sarebbero concentrati ai poli in precipitazioni solidificate dalle bassissime temperature. Anche l' ossigeno sembra non aver dato traccia di sé durante gli esami da parte del laboratorio di bordo; esso è apparso solo sotto forma di *ozono*, evidente risultato dell'irradiazione ultravioletta proveniente dal Sole, che giunge quasi liberamente fino al suolo. L'ossigeno molecolare è stato pressoché completamente assorbito dalle polveri e dal terreno, ove è stato infatti rintracciato, come s'è già visto, in quantità superiori al previsto. Il luogo in cui si è depositato il modulo LANDER del VIKING 2 non differisce sostanzialmente dal deserto di *Chryse:* la ragione appare altrettanto inospitale e molto più costipata di massi, alcuni dei quali, evidentemente capitati sotto le piastre d'appoggio, hanno determinato l'assetto inclinato del modulo. Le prime due fotografie inviate alla base di Pasadena subito dopo il contatto, hanno generato sensazione perché si supponeva che la regione fosse ricoperta di estese dune sabbiose. « È una foresta di rocce » ha esclamato invece Thomas Mutch, il capo dell' équipe preposta alla ricerca del luogo d'approdo. Le temperature misurate nel deserto d'*Utopia* sono state di —89° e di —37°, sensibilmente più basse, almeno riguardo al massimo, di quelle riscontrate nella *Depressione di Chryse:* il fatto è connesso alla latitudine più inoltrata del luogo in cui il secondo LANDER è disceso. L'attività sismica del suolo marziano è stata seguita con molto interesse dalla base, anche perché non era stato possibile disporre al funzionamento il sismometro del primo LANDER. Una certa attività è stata osservata ma, finora, essa è attribuita alle crude vicende termiche a cui son sottoposti gli strati più superficiali del terreno che tendono ad espandersi ed a fratturarsi.

La regione di Chryse, *scavata da larghi canaloni, è la muta testimonianza di un passato ricco di acque correnti. (Ripresa dal MARINER 9).*



Le esperienze biochimiche sui campioni di terriccio sono state ripetute anche con il laboratorio del VIKING 2 ed hanno dato i medesimi risultati: nessuna traccia conclusiva di composti organici, anche se si è verificata una notevole liberazione d'ossigeno e di biossido di carbonio. Molti specialisti ritengono che questo sia dovuto ad un'attività chimica del suolo assai ricco, per assorbimento, di quei gas, piuttosto che ai prodotti di microrganismi di tipo anaerobico (cioè, viventi in assenza d'ossigeno): d'altra parte, essi sostengono, i venti alla superficie di Marte sono abbastanza impetuosi e costanti, e trascinano via continuamente grandi masse di materiale polverulento così da non consentire, alle eventuali forme biologiche, una stasi sufficiente alla produzione percettibile di tracce organiche. A questo proposito i primi risultati sugli esperimenti del VIKING 2 hanno chiarificato parzialmente quelli ottenuti in precedenza

NationalGeographic TV

NASA; NASA/JPL/CALTECH (IN ALTO A DESTRA)

NG CHANNEL

Alla scoperta del pianeta rosso

A bordo dei rover della Nasa

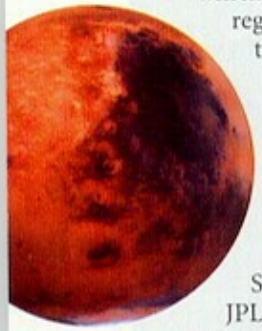
La ricerca della vita su Marte è diventata quasi un'ossessione per noi terrestri. Dagli anni Sessanta in poi, abbiamo utilizzato le tecnologie più sofisticate nella speranza di rilevare qualche traccia di vita aliena sul pianeta rosso. E i rover della Nasa (sopra), sofisticati veicoli robotici che dovrebbero posarsi su Marte proprio in questi giorni, rappresentano la tappa più recente di questa febbrile ricerca. Ricco di riprese esclusive e di straordinarie ricostruzioni 3-D, il documentario *Viaggio su Marte: l'atterraggio*, in onda su NG Channel l'11 gennaio alle ore 21.00, segue il progetto rover della Nasa fin dall'inizio, svelando tutti i suoi retroscena e analizzando tutte le sue possibili implicazioni. Un dettagliato dietro le quinte di una missione fra le più promettenti della storia dell'esplorazione spaziale.

National Geographic Channel
In onda su SKY **Viaggio su Marte: l'atterraggio**
Domenica 11 gennaio alle ore 21.00

■ Gli orari dei programmi sono soggetti a variazioni: per informazioni più dettagliate sulla programmazione quotidiana, consultate i palinsesti locali

likely to be concentrated at these high latitudes, and they should be near the surface." Based on the amount and depth of any water ice that MVACS finds, scientists should be able to infer how much water is locked up in the soil over the entire planet, which in turn will shed light on how much liquid water existed in the past.

Besides looking for volatiles, MVACS could see evidence of layering in the one-meter-deep trenches excavated by the robotic arm. If scientists are correct in estimating the rate at which ice and dust are being deposited in the polar regions, one meter of sediment should correspond to a 100,000-year record of climate change on Mars. In a best case scenario, the robotic arm's high-resolution imager will see fine-scale annual layering reminiscent of tree rings.



Mars Polar Lander will differ from Mars Pathfinder in one other major respect: No rover will be tagging along. "There are two ways to explore the surface of Mars," explains Mars Surveyor '98 project manager, John McNamee of JPL. "If you're looking for rocks, the best way to go is horizontally, and a rover is the right thing to do that. But if you're looking for water and climate history, digging straight down is the way to go."

As it's parachuting to the surface, Mars Polar Lander will take what could be spectacular images of the surrounding terrain with the Mars Descent Imager (MARDI), giving scientists a geological and physical context for the lander's immediate vicinity. Once on the ground, MARDI will resolve tiny soil particles directly below the lander.

The Russian Space Agency has supplied the Light Detection and Ranging (LIDAR) instrument, which will bounce laser pulses off clouds to determine their composition and measure atmospheric dust content. LIDAR is the first Russian-built instrument to fly aboard an American planetary mission.

The Planetary Society and Caltech have devised a palm-sized microphone to pick up sounds audible to the human ear as well as some lower frequencies. According to the Planetary Society's executive director Louis Friedman, the device will be able to hear "machinery, wind, dust blowing against rocks, and who knows what else."

The two 5.5-pound (2.7 kg) penetrators piggybacking on Mars Polar Lander will fit inside basketball-sized aeroshells. They will be released just prior to the lander's atmospheric entry. With no parachutes or braking thrusters, these microprobes will slam into the surface at roughly 450 miles (700 km) per hour and bury themselves up to 3 feet (1 meter) deep. Part of the NASA/JPL New Millennium project to develop miniaturized spacecraft for the 21st century (see "Deep Space 1 Set for Asteroid Visit," page 57), the "Deep Space 2" microprobes carry a simplified version of TEGA to look for water ice underground. They will also measure soil temperatures and look for layers in the soil. The probes are designed to function for one to three days.

"Ultimately you could launch fleets of these things," says Deep Space 2 project manager Sarah Gavit of JPL. "You'd have one mother ship with 10 or 15 penetrators. You could disperse them across a planet and get data from different locations, which is important if you're trying to understand the meteorology of the planet or its seismic activity."

The truly remarkable aspect of Mars Surveyor '98 is its size, or lack thereof. The lander weighs in at 1,250 pounds (570 kg), roughly half a Viking lander and about two-thirds Pathfinder's weight. The orbiter is the size of a telephone booth and weighs only 1,400 pounds (630 kg). Cost is another difference. "On the Viking project we spent billions and billions in today's dollars to do this kind of thing. This

Mars Polar Lander will use its robotic arm to dig several feet deep into the layered terrain of Mars's polar regions, seen in this Viking 2 image.

NASA/JPL

NASA/JPL

Mars Climate Orbiter will function as a weather satellite for a full martian year — the equivalent of almost two Earth years.

USGS

A mid-course rocket firing in July will aim Mars Polar Lander toward its exact landing site near the edge of Mars's south polar cap.

beautiful Mars Global Surveyor images. Mars Global Surveyor's cameras were designed to take high resolution views in one color. The Mars Color Imager (MARCI) aboard Mars Climate Orbiter will obtain only low and medium resolution pictures, but in many colors, enabling it to identify atmospheric features as well as sense color variations on the surface. MARCI weighs only 5 pounds (2.2 kg) and is as small as a pair of hand-held binoculars.

The information gleaned from the orbiter about Mars's present-day climate will prove crucial for understanding the past climate. "We're using the seasonal change as a proxy for climate changes that occurred over much longer periods of time," says Richard Zurek of the Jet Propulsion Laboratory, the Mars Surveyor '98 project scientist. "If we can model the physical processes correctly, then we can extrapolate those back into the past."

More than Skin Deep

Mars Polar Lander will touch down near the northeast boundary of the "layered terrain" that surrounds the south pole, between a latitude of 75° and 78°. The layered terrain is unique to Mars's polar regions and appears from orbit to be terracelike layers of frost interspersed with layers of dust. Mars's seasonal dust storms are thought to deposit a thin veneer of dust on the polar caps. As winter advances, carbon dioxide and water ice coat the dust. Over eons, many layers build up and are then sculpted by the wind into linear features that snake across the polar wilderness for hundreds of miles. Orbital images show layers roughly 160 feet (50 meters) thick, which were probably deposited during warm and cold spells lasting tens of thousands of years. "These layers preserve a record of Mars's climate history," says Ralph Lorenz of the University of Arizona, who works with both the lander and penetrator mission science teams.

Scientists don't know what this alien environment will look like from the surface, but it should appear dramatically different from the Viking and Pathfinder sites. The lander will arrive in the southern hemisphere's late spring, when carbon dioxide ice in the southern polar cap is turning into vapor. "We will see frost and maybe fog," predicts Lorenz. Mars Polar Lander should function for at least 90 days on the martian surface before the batteries freeze.

The lander's primary instrument package, Mars Volatiles and Climate Surveyor (MVACS), is not designed to search for life. But it may find clues as to whether past conditions were favorable for life. MVACS will do this by searching for volatiles — substances such as water and carbon dioxide that can move around a planet by evaporating in one place and condensing into a solid in another. MVACS consists of a 6.6-foot-long (2 meter) robotic arm, a stereo color imager similar to the one aboard Pathfinder, an advanced meteorology boom, and a complex experiment known as Thermal and Evolved Gas Analysis (TEGA).

The robotic arm is the first to visit Mars since Viking. Designed and built by NASA's Jet Propulsion Laboratory, the arm has been integrated into the rest of the spacecraft by the lander and orbiter's prime contractor, Lockheed Martin Astronautics in Denver, Colorado. "The robotic arm will be able to dig almost a meter down if the soil is soft enough. It has an elbow and shoulder joint, so it is a much more capable system than the one Viking had," says Lockheed Martin's Ed Euler, program director for Surveyor '98. The arm also has a camera on the end that can resolve individual grains of sand.

The robotic arm will deliver up to eight soil samples to TEGA. An oven will cook the samples, freeing gases and water trapped inside. A laser spectrometer will detect the gases that are driven off. Thermal changes will indicate water-bearing minerals that may have formed during periods when there was liquid water on Mars.

David Paige of UCLA, MVACS's principal investigator, says the landing site was chosen for one overall reason: temperature. "It's cold down there; temperatures will average around –100° F (–72° C). Because of that, we have a better chance to actually touch volatiles with the lander. They are

symmetry of the vision itself around the plane passing through the Earth-Moon axis and orthogonal to the Moon's orbital plane.

3) Of course, L2 may not be utilized at all, since it faces crater Daedalus just at the latter's zenith. Any RFI-producing device located at L2 would flood the whole of the Farside, and must be ruled out. L2, however, is the only Lagrangian point to be kept free, out of the five located in the Earth-Moon system. Finally, L2 is not directly visible from the Earth since shielded by the Moon's body, which calls for "leaving L2 alone"!

Figure 4 shows this author's Proposal for utilizing both the Moon (Nearside and Farside) and four out of the five Earth-Moon Lagrangian Points (L1, L3, L4 and L5) at the same time ***without creating conflicts between these quite diverse utilizations.***

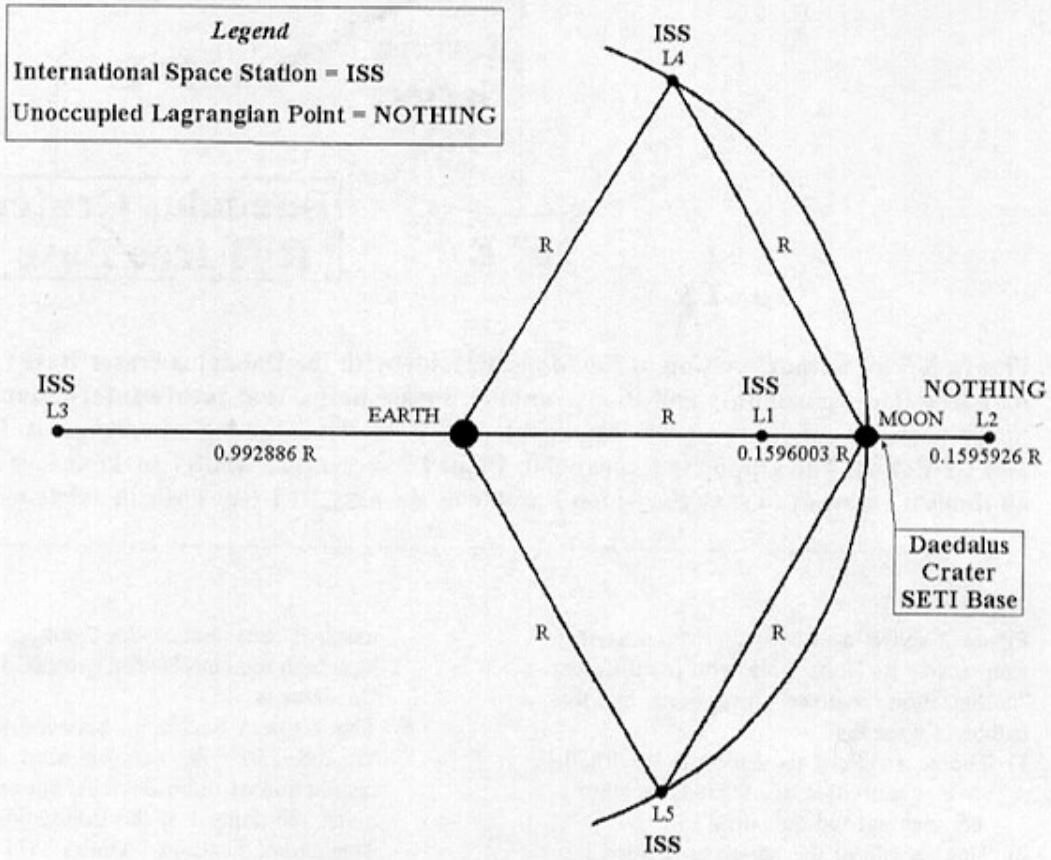


Figure 4. This author's Proposal for utilizating both Moon and Lagrangian Points.

5. The further two Lagrangian Points L1 and L2 of the Sun-Earth System: their "unfortunate" action on the Moon Farside

There still is an unavoidable drawback. This comes from the ***further two Lagrangian points L1 and L2 of the Sun-Earth system***, located along the Sun-Earth axis and outside the sphere of influence of the Earth, that has a radius of about 924646 km around the Earth. Precisely, the Sun-Earth L1 point is located at a distance of 1496557.035 km from the Earth towards the Sun, and the L2 point at the (virtually identical) distance of 1496557.034 km from the Earth in the direction away from the Sun, that is toward the outer solar system. These two points have the "nice" property of moving around the Sun just with the same angular velocity as the Earth does, while staying also at the same distance from the

7. The "Lunar SETI Cosmic Study" left unfinished by Jean Heidmann in July 2000

At the time Jean Heidmann untimely passed away (July 3, 2000), he had received a total of 26 papers and abstracts of papers from contributors to the "Lunar SETI Cosmic Study" that he was coodinating.

In October 2000, during the IAF Congress held in Rio de Janeiro, the Academy took the decision to transfer the Study coordination to the present author. Jean Heidmann's widow, Mme. Marie-Ange Heidmann, kindly had already handed over all the papers that her husband had received.

Later, this author rearranged the whole set of documents he had received into seven categories covering different aspects of the intended Moon Farside Study. These are:

1) **RFI on Earth.** A paper by Prof. D. McNally (University of Hertfordshire, UK) entitled "Electromagnetic Pollution at Radio Wavelengths"
2) **ITU and Frequency Management.** A description by Prof. Rosa M. Ramirez de Arellano (Univ. of Mexico City) of the preparatory work for the ITU Meeting held at Istanbul (May 8 – June 2, 2000). Also, an abstract by E. Gérard (Meudon) about keeping the 0-50 GHz window "Open for Radio Astronomy"
3) **Lunar Farside in General.** A paper by Prof. Stanislaw Gorgolewski (Torùn Radio Astronomy Obserbatory, Poland) entitled "Highest Sensitivity Radio Astronomy and SETI from the Farside of the Moon (including Crater SAHA)". A paper entitled " Protection for a Lunar Radio Observatory" by Prof. John B. Whiteoak (CSIRO, Epping, Australia). The Abstract of a paper entitled "On the Possible Strategy on Establishing SETI-Base on the Farside of the Moon", by Prof. Olexii V. Perekhod, Kiev, Ukraine
4) **Orbits Around the Moon and the L1, L2 Sun-Earth Lagrangian Points.** One more paper by Prof. Gorgolewski entitled "Future Space VLBI on Lunar Orbits in the Radio Shadow on the Farside of the Moon". A paper by Robert L. DeBiase (Staten Island, New York) entitled "The need for a Consensus on the Use of Electro-magnetic Spectrum Beyond Terrestrial Near Space"
5) **Saha-Related Space Technology.** A paper by Prof. Giancarlo Genta (Turin Politecnico, Italy) and co-workers Maria A. Perino and Stefano Cesare (Alenia Spazio S.p.A., Turin) entitled "The Laser Data Link For the Saha Radioastronomic Mission". A paper by Dr. Salvatore Santoli (International Nanobiological Testbed Ltd., Rome, Italy) entitled "A Robotic, Nano-To-Micro Integrated Fluidics "Lab-On-Chip" Lunar Rover for Fast and Cost-Effective Environ-mental Analysis"
6) **Legal Aspects.** A paper by Prof. Francis Lyall (University of Aberdeen, Scotland, UK) entitled "A Lunar Far-side Observatory and the Law". A paper by Dr. Bess Reijen, International Institute of Space Law, entitled "The 1979 Moon Agreement and SETI Research". A first paper by Drs. Patricia M. Sterns and Leslie I. Tennen of the Law Officies of Sterns and Tennen, Phoenix, AZ, USA, entitled "International Law and the Lunar Crater Saha Proposal". A second paper by the same authors entitled "Should the Lunar Crater Saha be Accorded Special Legal Protection?"
7) **Philosophical Aspects.** A paper by Prof. Gregory L. Matloff of the Pace University and New York University entitled "Sharing the Moon: A Call for Environmental Ethics and Resources".

This collection of papers was the only material available for the Cosmic Study when Heidmann left us.

Not quite enough to make a Cosmic Study of the International Academy of Astronautics (IAA) as such a Cosmic Study is traditionally understood.

In fact, what an IAA Cosmic Study must be is clearly described at the web site of the IAA (http://www.iaanet.org/p_papers/) as follows.

Cosmic Studies

"As world leaders discuss a future in space that includes ambitious multinational projects such as a lunar base and the eventual colonization of Mars, the Academy has embarked upon a series of cosmic planning studies to provide decision-makers an unbiased scientific and technological basis for their commitment to these programs. These multidisciplinary cosmic studies, reviewed by one thousand academicians from 60 countries, are examining alternatives for international cooperative ventures and their probable impact on the economic and social life of the nations involved."

It was thus felt that it was necessary to widen the scopes of the former "Lunar SETI Cosmic Study"as follows:

1) The whole of Radio Astronomy, and not just SETI, was to be encompassed by the Study. This is particularly significant since, apart from the obvious shielding from man-made RFI, the Farside of the Moon would enable us to ***explore for the first time all radio frequencies lower than 15 MHz,*** forbidden to us by the ionosphere surrounding the Earth. Unexpected discoveries could arise from this "getting rid of the ionosphere" for the progress of science and astrophysics
2) Jean Heidmann was probably not aware that many studies to exploit the Moon Farside for Radio Astronomy, VLBI and Astrophysics had already been conducted by the Jet Propulsion Laboratory and related institutions. The author of this paper is thus indebted to his deputy in this Study, Dr. Mike Davis of the SETI Institute, for pointing this out clearly and for putting him in touch with the experts. Much more work is required

---

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6 rue Galilée, BP 1268-16, 75766 Paris Cedex 16
Tel 331 47 23 82 15, Fax 331 47 23 82 16
Web site http:/www.iaanet.org
sgeneral@iaanet.org

Paris, March 14, 2001

Prof. Claudio Maccone
Via Martorelli 43
10155 Torino, Italy

Dear Prof. Claudio Maccone,

I am happy to inform you that, under proposition of Prof. Gerhard Haerendel, Vice-President Scientific Programs, the IAA Board of Trustees in its session on 03 October 2000 approved your nomination to conduct the study on

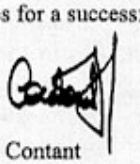
Laboratory on Far Side of the Moon
(title to be confirmed)

We would like you to revise the strategy and schedule, which were developed by the late Prof. Jean Heidemann, but in addition we would like to receive your suggestions of potential sponsors.

We look forward to receiving an updated list of names of group members and of the secretary in the official Study Group form available from the IAA Web site restricted section.

With best wishes for a successful study,

Sincerely



Dr. Jean Michel Contant
Secretary General

Copies: Dr. M. Yarymovych, Prof. G. Haerendel

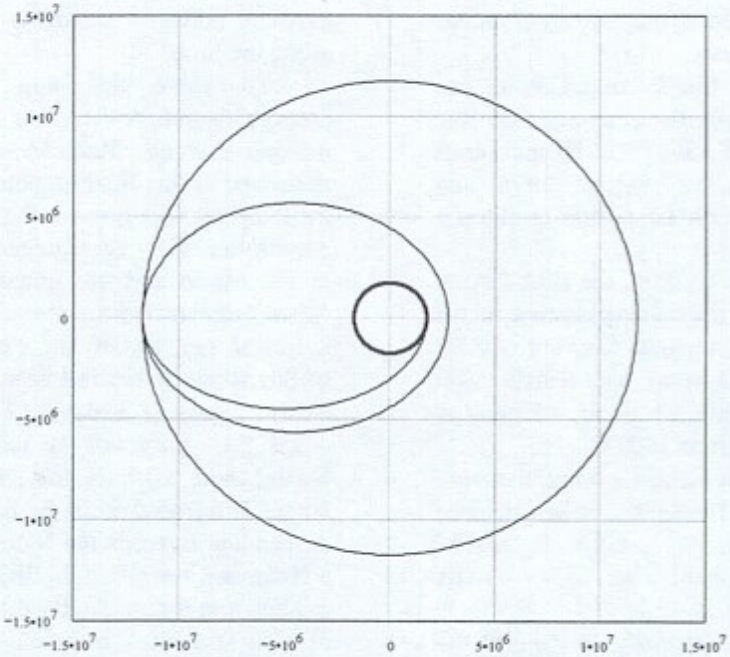


Figure 5. Circling and Landing Orbits of the SETImoon Mission to the Moon.

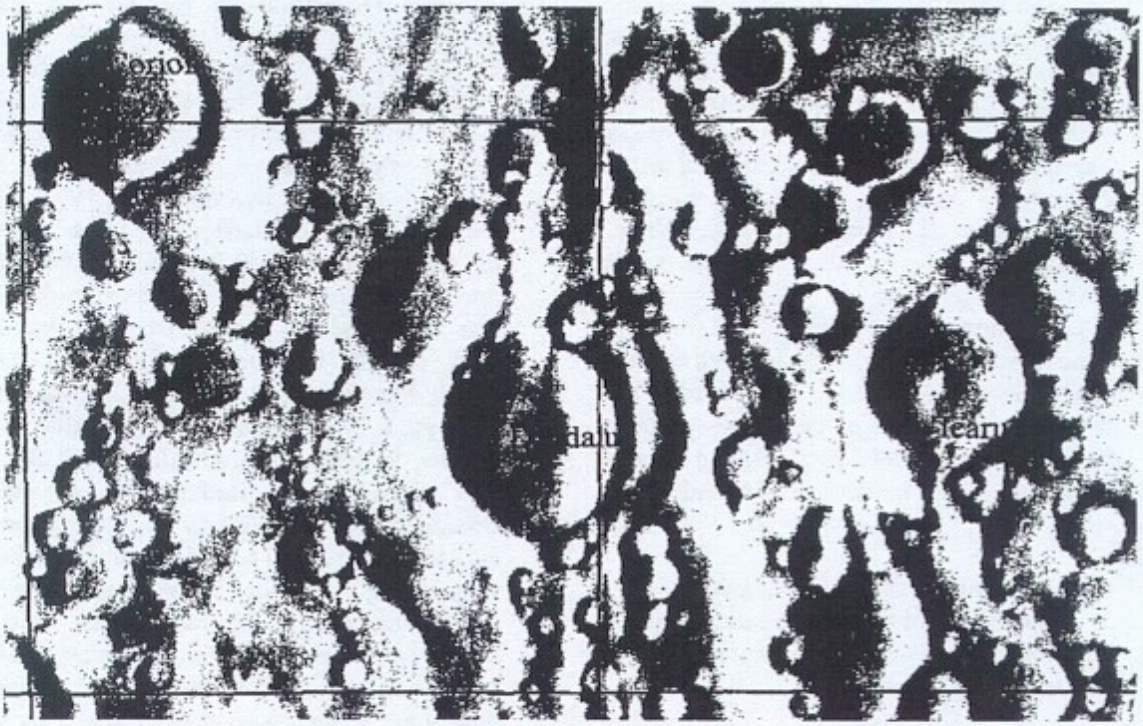


Figure 6. Crater Daedalus, the crater located nearest to the Earth's antipode on the farside of the Moon. This figure shows the Moon's equator (horizontal line at the top of the figure) and the 180° E meridian (the central vertical line). They cross at the Earth's antipode but the Moon's soil there is too rugged to place a base. Thus, one is forced to select crater Daedalus, located about 5° South of the equator but crossed by the 180° E meridian, as the best possible farside Moon base close to the Earth's antipode. Crater Daedalus is about 100 km in diameter, just as crater Saha.

Earth at all times. Thus, they are ***ideal places for scientific satellites***.

Actually, the Sun-Earth L1 Point has already been in use for scientific satellite location since the NASA ISEE III spacecraft was launched on 12 August 1978 and reached the Sun-Earth L1 region in about a month.

On December 2, 1995, the ESA-NASA "Soho" spececraft for the exploration of the Solar Corona was launched. On February 14, 1996, Soho was inserted into a halo orbit around the Sun-Earth L1 point, where it is still librating now (June 2001).

As for the Sun-Earth L2 point, there are plans to let NASA's SIM (Space Interferometry Mission) satellite be placed there, as will probably be ESA's GAIA astrometric satellite as well.

So, all these satellites do "spoil" the otherwise RFI-free Farside of the Moon when the Farside is facing them. Unfortunately, the Moon Farside is facing the Sun-Earth L1 point for half of the Moon's synodic period, about 14.75 days, and it is facing the Sun-Earth L2 point for the next 14.75 days. Really all the time!

This radio pullution of the Moon Farside by scientific satellites located at the Lagrangian Points L1 and L2 of the Sun-Earth system is, sadly, UNAVOIDABLE. We can only hope that telecom satellites will never be put there. As for the scientific satellites already there or on the way, the radio frequencies they use are well known and usually narrow-band. This should help the Fourier transform of the future spectrum analyzers to be located on the Moon Farside to get rid of these transmissions completely.

6. Proposing "RadioMoon": A New Space Mission to Set up and Operate an RFI-free Base inside Crater Daedalus Robotically

A new problem is that it will hardly be possible to link the base at crater Daedalus to other bases on the Moon visible side by virtue of optical fibers or landed data relays, because of the large distance of 2730 km existing between Daedalus and anywhere along the limb.

To solve this new problem, the proposal is put forward here for a new space mission dubbed "RadioMoon" and briefly described in this final section. RadioMoon is made up by two spacecrafts: one lander and one orbiter. They fly together from the Earth to the Moon and are initially parked in a Moon circular and equatorial orbit having a radius of, say, 10,000 km. The orbital period of this single spacecraft around the Moon is 31.641 hours (2.3 days). Then, at a time when the spacecraft is just crossing the Earth-Moon axis on the visible side, the lander is released from the orbiter and starts descending towards the Moon surface along a Hohmann transfer half-elliptical trajectory, as shown in Figure 10. By the very definition of this Hohmann transfer, the lander just lands at the longitude of 180° E, namely inside crater Daedalus (slightly different maneuvers there would slow down the impact). The Hohmann transfer has the parameters: semimajor axis 6378 km, eccentricity 0.742, time to get down from 10,000 km along the half-ellipse 6 h 52.86 m. The lander would be protected by airbags against impact damage. We know that such airbags worked out well on July 4, 1997, for the Mars Pathfinder landing on Mars. Since the gravity on the Moon is about a half of the gravity on Mars, there is no reason to doubt that such an airbag-protected landing would work equally well on the surface of the Moon. Finally, after touch down, the lander deploys a flat phased array capable of steering its beam electronically for all RFI-free Searches in Radioastronomy and Bioastronomy. The orbiter's task is to gather data from the phased array at crater Daedalus when flying above the Farside, and transmit these data back to the Earth when flying above the near side. And the other way round for giving the Earth's instructions to the phased array operations at Daedalus. This is by far the cheaper, easier and safer way to operate a Moon Farside base from any astronautical point of view.

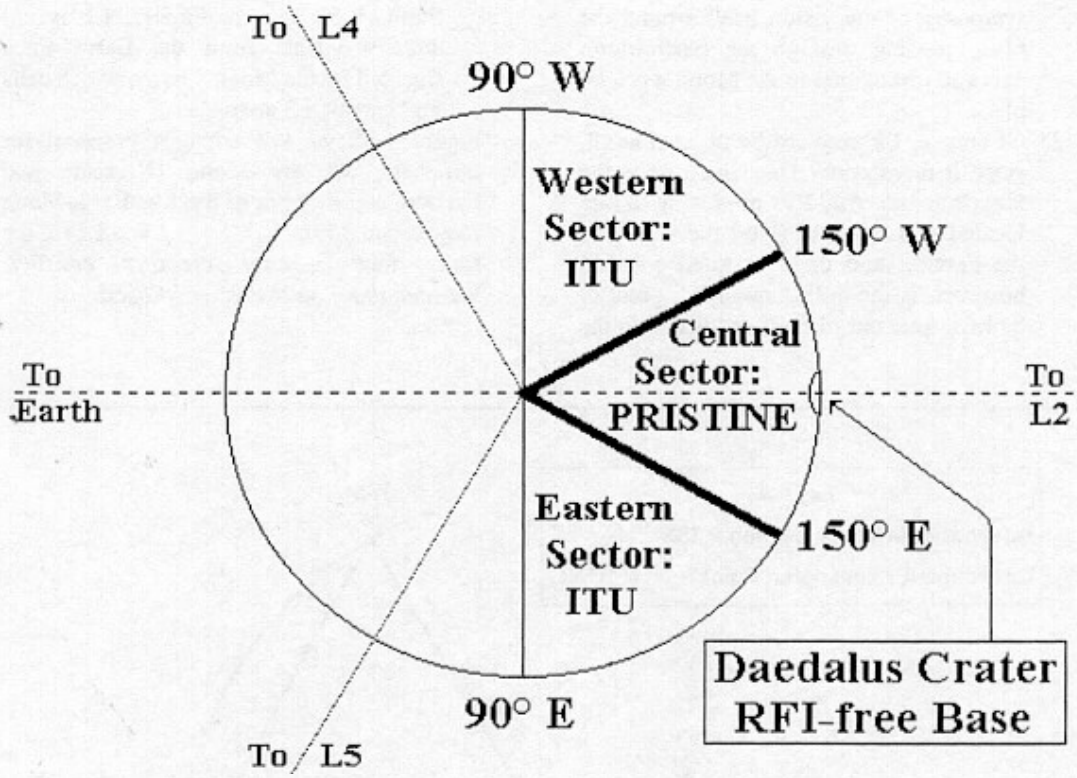


Figure 3. This author's vision of the Moon Farside with the Daedalus crater Base for RFI-free Radioastronomy and Bioastronomy. Please notice that future International Space Stations might freely be constructed at both the Lagrangian triangular L4 and L5 Points. The Opposite Lagrangian Point L2, however, MUST be kept free at all times if we want to save the Moon Farside as the only RFI-free oasis in existence!

Figure 3 shows a map of the Moon as seen from above its North Pole with the different "colonization regimes" proposed by this author. We see that:

1) The near side of the Moon is left totally free to activities of all kinds: scientific, commercial and industrial
2) The Farside of the Moon is divided into thirds, three sectors covering 60° in longitude each, out of which:
   a) The Eastern Sector, in between 90° E and 150° E, can be used for installation of radio devices, but only under the control of the International Telecommunications Union (ITU-regime)
   b) The Central Sector, in between 150° E and 150° W, must be kept totally free from human exploitation, namely it is kept in its "pristine" radio environment totally free from man-made RFI. This Sector is where crater Daedalus is, a ~ 100 km crater located in between 177° E and 179° W and around 5° of latitude South. At the moment, this author does not know how high the circular rim surrounding Daedalus is
   c) The Western Sector, in between 90° W and 150° W, can be used for installation of radio devices, but only under the control of the International Telecommunications Union (ITU-regime).

Also:

1) The Eastern Sector is exactly opposite to the direction of the Lagrangian point L4, and so the body of the Moon completely shields the Eastern Sector from RFI produced at L4. Thus, L4 is fully "colonizable"
2) The Western Sector is exactly opposite to the direction of the Lagrangian point L5, and so the body of the Moon completely shields the Western Sector from RFI produced at L5. Thus, L5 is fully "colonizable" in this author's vision, whereas it was not so in Heidmann's vision. In other words, this author's vision achieves the ***full bilateral***

by (2.3) upon replacing R= 323050 km, and the result is

$$\lambda = 154.359° . \qquad (3.1)$$

In words, this means the following basic, new result:

the Moon Farside Sector in between 154.359 E and 154.359 W will never be blinded by RFI coming from satellites orbiting the Earth alone.

In other words once again, the ***limit*** of the blinded longitude as a function of the satellite's orbital radius around the Earth is 180° (E and W longitudes just coincide at this meridian, corresponding to the "change-of-date line" on Earth). But this is the ***antipode*** to Earth on the Moon surface, that is the point exactly opposite to the Earth direction on the other side of the Moon. And our theorem simply proves that the antipode is the most shielded point on the Moon surface from radio waves coming from the Earth. An intuitive and obvious result, really.

So, where are we going to locate our SETI Farside Moon base? Just take a map of the Moon Farside and look. The antipode's region is depicted on the Hallwag map of the Moon (dated 1982, ref. [5]). One notices that the antipode's region (at the crossing of the central meridian and of the top parallel in the figure) is too a rugged region to establish a Moon base. Just about 5° South along the 180° meridian, however, one finds a large crater about 100 km in diameter, just like Saha. This crater is called Daedalus. So, ***this author proposes to establish the first RFI-free base on the Moon Farside just inside crater Daedalus, at 180° E. This is indeed the most shielded crater of all on the Moon Farside from our radio emissions!***

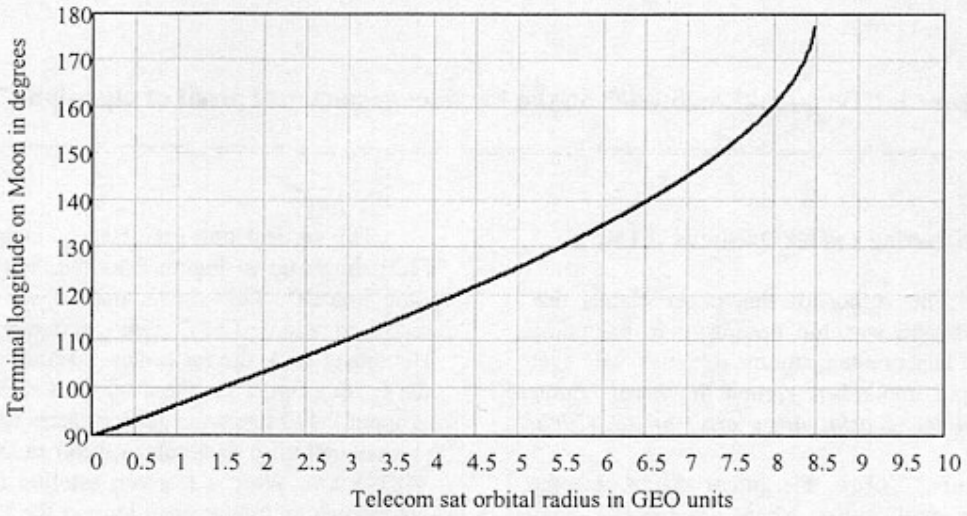


Figure 2. Terminal longitude (vertical axis) on the Moon Farside for the region still flooded by radio waves emitted from a telecommunications satellite put in a circular orbit around the Earth at a distance *R* (horizontal axis), in units of the Earth's geostationary radius (42241.096 km).

4. This author's vision of the Moon Farside for RFI-free Searches

Let us replace the 154.359° of equation (2.5) with the simpler value of 150°. This matches perfectly with the need to have the borders of the Pristine Sector making angles orthogonal to the directions of L4 and L5. The result is this author's vision of the Farside of the Moon, shown in Figure 3.

Replacing into (2.3) the value of the geostationary radius, R=42241.096 km, one finds for the Moon Farside terminal longitude λ the value

$$\lambda = 96.525^\circ . \qquad (2.5)$$

This is how Heidmann came to select and propose crater Saha: he just used the above (unpublished, but obvious) argument to compute that the longitude of the needed crater had to be higher than the 96.525° value given by (2.5). Then, allowing a little more tolerance of about 5° in longitude for further shielding by the Moon's body, finally declared in [1] that Saha was the "best" crater to establish a Lunar SETI base. Then, for six years (1994-2000), no one thought of questioning Saha as "best" crater. But this author holds a different view.

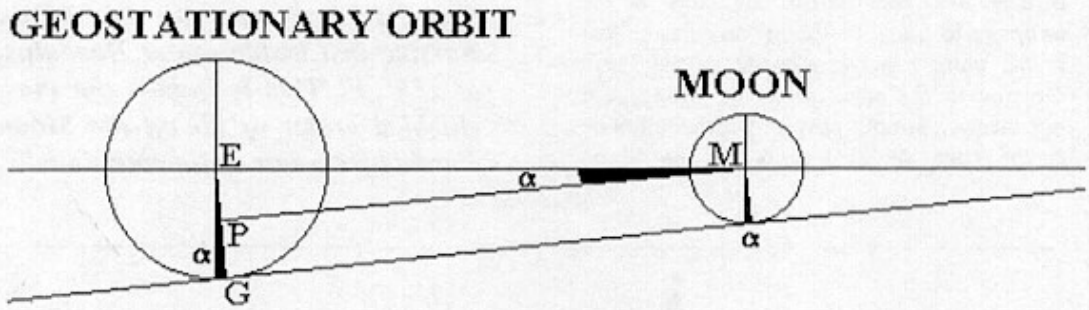


Figure 1. "Terminal Longitude" on the Farside: geometrical proof of equation (2.3).

3. Selecting Crater Daedalus at 180° E

The author of this paper claims that Heidmann was too optimistic in excluding that telecommunications satellites will ever be put into orbits around the Earth ***higher than the geostationary orbit of 42241.096 km.***

In other words, this author claims that the time will come when commercial wars among the big industrial trusts running the telecommunications business by satellites will lead them to grab more and more space around the Earth, pushing their satellites into orbits with apogee much higher than the geostationary one, with the result that ***crater Saha will be blinded as soon as a company decides to go higher than the geostationary orbit.*** The last remark is important for Bioastronomers. If we, the supporters of Bioastronomy, bet everything on a SETI and Bioastronomy Base located at Saha, then we may lose everything pretty soon!

A "safer" crater must be selected further East along the Moon equator. How much further East?

The answer if given by the diagram in Figure 2, based on equation (2.3).

The vertical trait predicted by equation (2.3) shows up in Figure 2 as the "upgoing right branch". This shows that, if we only take equation (2.3) into account (as Heidmann did), the maximum distance from the Earth's center for these telecom satellites is about 8.479 times the geostationary radius, corresponding to a circular orbital radius of 358148 km. Were a telecom satellite to be put in such a circular orbit around the Earth, its radio waves would flood Moon longitudes as high as about ~175° or more. However, here a surprise comes.

We have not considered the Lagrangian points yet!

So, it will never be possible to put a satellite into a circular orbit around the Earth at a distance of 358148 km, simply because this distance already lies beyond the distance of the Lagrangian point L1 nearest to the Earth, that is located at 323050 km (Lagrangian points are, by definition, the points of zero orbital velocity in the two-body problem!).

So we are now led to wonder: what is the Moon Farside terminal longitude corresponding to the distance of the nearest Lagrangian point, L1 ? The answer is given

1. Historical Introduction: Jean Heidmann's 1994 Proposal for a SETI Base in the Saha Crater

Bioastronomical signals searched for by radioastronomers fall into two classes:

1) Radio signatures of molecules important to the development of life, like the water maser at 22 GHz, and so on.
2) SETI (= Search for ExtraTerrestrial Intelligence) signals, narrowband signals broadcast by unknown extraterrestrial civilizations that may possibly live in the Galaxy or elsewhere.

In order to detect signals of either types, it is mandatory first to reject all RFI (Radio Frequency Interference). RFI, however, is produced in ever increasing amounts by the technological growth of civilization on Earth, and has now reached the point where large bands of the spectrum are blinded by legal or illegal transmitters of all kinds.

Since 1994, the late French radio-astronomer Jean Heidmann had pointed out (see refs. [1], [2], [3]) that Radioastronomy from the surface of the Earth is doomed to die in a few decades if uncontrolled growth of RFI continues. Heidmann also made it clear, however, that advances in modern space technology could bring Radioastronomy to a new life, were Radioastronomy to be done from the Farside of the Moon, obviously shielded by the Moon's spherical body from all RFI produced on Earth. Heidmann proposed that a radiotelescope should be placed inside the "Saha" Moon Farside crater, a ~ 100 km crater located in between 101° E and 105° E and around 2° of latitude South, surrounded by a 3000 m high circular rim. An Earth-pointing antenna sould also have to be located in the Nearside Mare Smythii plain, linked to Saha "conveniently". Since 1994, this author and other studied the link between Saha and Mare Smythii, and suggested it be made by either optical fibers (plus a "tether" for the descent-on-the-Moon maneuver) or by a few relay stations to be landed on the Moon surface. The relevant space mission, however, is hard to design at a low cost (ref. [4]).

2. A Mathematical Formula for the Terminal Longitude on Moon Farside: Reach of Waves from Earth Orbit

In this section we prove an important mathematical formula, vital to select any RFI-free Moon Base on the Farside.

We want to compute the small angle α beyond the limb (the limb is the meridian having longitude 90° E on the Moon) where the radio waves coming from telecommunications satellites in circular orbit around the Earth still reach, i.e. they become tangent to the Moon's spherical body. The new angle $\lambda = \alpha + 90°$ we call the "terminal longitude" of these radio waves. In practice, no radio wave from telecom satellites can hit the Moon surface at longitudes higher than this terminal longitude.

To find α (see Figure 1) we draw the straight line tangent to the Moon's sphere from G, the point tangent to the circular orbit having radius R. This straight line forms a right-angled triangle with the Earth-Moon axis, EM, with right angle at G. Next, consider the straight line parallel to the one above but from the Moon center M, intersecting the EG segment at a point P. Once again, the triangle EPM is right-angled in P, and it is similar to the previous triangle. So, the angle α is now equal to the EMP angle. The latter can be found, since:

1) We know the Earth-Moon distance, $\overline{EM} = D_{Earth-Moon}$, and we assume its worst case (Moon at perigee): Earth-Moon distance equal to 356410 km.
2) The $\overline{EP}$ segment equals the $\overline{EG} = R$ segment minus the Moon radius, R_{Moon}.
3) Using Pythagoras' theorem one finds
$$\overline{PM} = \sqrt{\left(\overline{EM}\right)^2 - \left(\overline{EP}\right)^2} \,. \qquad (2.1)$$
4) The tangent of the requested angle α is then given by
$$\tan\alpha = \frac{\overline{EP}}{\overline{PM}} = \frac{\overline{EP}}{\sqrt{\left(\overline{EM}\right)^2 - \left(\overline{EP}\right)^2}} \,. \qquad (2.2)$$

In conclusion, by inverting (2.2) and making the substitutions described at the points 1), 2) and 4) of this discussion, one gets the terminal longitude λ of radio waves on the Moon Farside (between 90° E and 180° E) emitted by a satellite circling the Earth at a distance R:

$$\lambda = \operatorname{atan}\left(\frac{R - R_{Moon}}{\sqrt{D_{Earth-Moon}^2 - \left(R - R_{Moon}\right)^2}}\right) + \frac{\pi}{2} \qquad \ldots(2.3)$$

Here the independent variable R can range only between 0 and the maximum value that does not make the radical in (2.3) become negative, that is

$$0 \le R \le D_{Earth-Moon} + R_{Moon} \,. \qquad (2.4)$$

Thus, the $\lambda(R)$ curve becomes vertical for $R \to \left(D_{Earth-Moon} + R_{Moon}\right)$, i.e. $\lambda = 180°$, it actually has its own stopping point there.

THE LUNAR SETI COSMIC STUDY OF IAA : CURRENT STATUS AND PERSPECTIVES

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ABSTRACT. The late French astronomer Jean Heidmann (1923-2000) was among the most distinguished supporters of SETI in the last decade. In particular, since 1992 he strongly advocated the use of the "Saha" crater, located on the far side of the Moon, as the best available place to operate a radiotelescope for radioastronomical and SETI searches in an environment free from man-made Radio Frequency Interference (RFI). In 1998, the International Academy of Astronautics (IAA) assigned Jean Heidmann the task of coordinating an IAA "Lunar SETI Cosmic Study" intended to point out the main new problems in the space sciences that would have to be addressed to position and operate a radiotelescope inside crater Saha. Jean Heidmann, however, untimely passed away on July 3rd, 2000, leaving the Cosmic Study unfinished. Subsequently, at the 51st International Astronautical Congress held in Rio de Janeiro (October 2-6, 2000(, the Academy decided to assign the task of completing the Lunar SETI Cosmic Study to the person writing these lines. Thus, the current status of the Lunar SETI Cosmic Study is described in this paper, and the prospects for completing it in a relatively short time are pointed out. It is believed that this Cosmic Study not only will pave the way for using the RFI-free far side of the Moon to the benefit of radioastronomy and SETI, but it will also try to provide suggestions for the basic issue of protecting such a unique environment from the RFI that would inevitably be produced by the commercial exploitation of the Moon. In fact, only by establishing a radio-telescope on the Farside of the Moon will it finally be possible to cope with the Radio Frequency Interference (RFI) that is now increasingly plaguing all Radioastronomy, Bioastronomy and SETI Searches done on Earth. In this paper, we also suggest a legal partition of the Farside into 3 sectors covering 60° each. In our view, this partition of the Moon's farside would ensure:

1) The creation of a Farside Moon Base inside crater Daedalus (at 180° E) with our Radiotelescope, rather than within crater Saha. This is because Saha is shielded only against RFI coming from telecom satellites in ***geostationary*** orbit around Earth, but not from RFI coming from higher Earth orbits. Seclecting Daedalus instead of Saha would solve the problem once and for all.
2) Complete freedom to exploit the Moon Nearside as well as the four Lagrangian Points L1, L3, L4 and L5 of the Earth-Moon system, where even some International Space Stations could be placed. However
3) The "opposite" Lagrangian Point L2 must be kept free from all spacecrafts, capable of blinding the whole Farside with their RFI.

In addition to replacing Saha by Daedalus and proposing that the Moon's Farside is legally protected as described, we also point out in this paper the enormous astrophysical benefits that doing Radioastronomy from the Moon's Farside promises. These were already studied in the USA by teams at Caltech/JPL and had not been previously taken adequately into account for inclusion within the IAA Cosmic Study. Actually, the whole of radioastronomy below 15 MHz (i.e. for wavelenghts higher than 20 m) is entirely to be discovered since the Earth's ionosphere just forbade any such search from the ground so far. Astrophysics could learn a lot from a Lunar Radiotelescope. Cosmology also could learn a lot, inasmuch as the tail of the Cosmic Microwave Background (CMB) could never be studied at low frequencies.

In conclusion, this Cosmic Study, now more appropriately renamed Cosmic Study for a "Lunar Farside Radio Lab", is offering a wonderful possibility not only for SETI, but also for many new investigations in Radioastronomy, in Astrophysics and in Cosmology.

Repubblica di San Marino
Ufficio di Stato per il Turismo

COMUNICATO

SAN MARINO: DALLA RICERCA DI VITA EXTRATERRESTRE AGLI UFO

Dall'8 al 10 marzo 2002 si svolgeranno a San Marino sotto l'egida della Segreteria di Stato per il Turismo e nella cornice del Teatro Turismo, due manifestazioni internazionali di notevole rilevanza scientifica, coordinate entrambe dal sociologo Roberto Pinotti.

Dalla mattina dell'8 a tutta la mattina del 9 marzo infatti, introdotta dalle Autorità sammarinesi, la terza edizione del **Simposio Mondiale sulla Esplorazione dello Spazio e la Vita nel Cosmo**, dedicato quest'anno al tema ***"Euroseti: dal SETI al SETV"***, ovvero ad un dibattito a 360 gradi sulla ricerca scientifica di civiltà extraterrestri (SETI) e addirittura a quella di possibili visite aliene (SETV), coinvolgente astronomi e radio-astronomi di frontiera in tutto il mondo.

Complementare rispetto a questa prima manifestazione, che vede la partecipazione attiva delle prestigiose *Seti League* e *Planetary Society* statunitensi, si svolgerà poi dal pomeriggio del 9 e fino alla sera del 10 marzo la decima edizione dell'annuale **Simposio Mondiale degli Oggetti Volanti non Identificati e i Fenomeni Connessi**, sul tema ***"Ufo, Ufologia e Riconoscimenti Istituzionali".***

Un aspetto indubbiamente fra i più coinvolgenti e inquietanti, che vedrà anche la partecipazione di delegati in rappresentanza di organismi preposti, in vari paesi del mondo, ad uno studio scientifico ufficiale o semiufficiale del controverso fenomeno, con particolare riferimento alla casistica relativa agli "incontri ravvicinati" fra Ufo e aerei in volo, militari e civili.

Una "tre giorni" di enorme interesse non solo per gli astrofili, gli ufologi e gli appassionati delle ricerche di frontiera in genere; ma anche per il grande pubblico, sempre più sensibile al concetto che l'uomo non è solo nell'universo.

L'Ufficio Stampa e p.r.

San Marino, 26 febbraio 2002/1701 d.F.R.

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A SETV ground based observatory requires astrophysical methodologies and analysis of a new and complex nature. There are inherent challenges when dealing with any new phenomenon. In particular, ETI interstellar probes may take forms that would not be recognised or even identified by us as technological. Ongoing analysis of data already obtained is necessary for further refining the range of equipment, taking into consideration the nature of the multifrequency instrumentation that will produce the most significant data and represent the best use of available funds.

In order to record a new phenomena a new approach in design criteria in instrumentation is necessary for success. We have to look at a broad range of possible targets that may not be obvious in their nature. Instrumentation already developed and produced at Kingsland Observatory is a significant modification of the commercial-off-the-shelf COTS approach to SETV as suggested by others.

This paper will focus on spectroscopy as related to SETV, with explanations why conventional devices are not suitable in this endeavour, and new design considerations needed to meet the specific challenges within this area of research.